Fermilab
FY2002 Self-assessment
Process Assessment Report
For
Technical Division

19-Sep-2002

Division/Section performing assessment
Technical Division

Name of organization that owns assessed process
Technical Division

Organization Strategy
As written in the 2000 Annual Program Review document, "The Technical Division has a business philosophy and the capability to integrate all aspects of a production task, including conceptual design, R&D, engineering, tooling design and fabrication, quality assurance, procurement, production, and product testing." When it comes to project management, the Technical Division is experienced and able to manage large HEP projects. Technical Division is currently participating in project management in many HEP projects, including CMS, LHC, High-field R&D, and Pierre Auger.

Names of Personnel on Assessment team
Jamie Blowers, Quality Assurance Officer

Name of process assessed
Project Management

Brief description of process to be assessed
Project Management consists of all the tools used in the management of specific tasks. For each project this can look very different, but there are underlying principles which are used on most projects, e.g. resource management, time management, work planning, quality assurance, et cetera.

Are metrics associated with this process? If so, what are they?

There are no contractual metrics associated with this process. Internal to most projects (and often linked back to the funding agency) are the tracking of cost and schedule against the plan.

What are the names of the procedures associated with this process?

There is no single document which describes the entire process. Here is a list of some of the documents which relate to project management for the TD portion of the US-CMS project:

Project Management Body of Knowledge (PMBOK)
US-CMS Project Management Plan
US-CMS Cathode Strip Chamber Quality Assurance Plan
TD Quality Management Program TD-2010
CMS-EMU FNAL Factory Division of Responsibilities
Statement(s) of Work
Memorandums of Understanding

Are these procedures being followed? Are they current?

The procedures are being followed. The Project took the underlying principles of project management, in conjunction with the business practices of the Division, and developed the methodology to use for planning and implementing the project within the Division.

Describe the methodology used to assess this process.

Project Management is such a large topic, that it was decided to conduct the assessment by reviewing how one project within the Division is being managed. We chose to review the TD portion of the US-CMS project. The methodology was to interview the project manager, and frame the dialogue around the table of contents found in the "Project Management Body of Knowledge."

Results of the assessment:

Based on this assessment, we conclude that the project management within the Technical Division should be rated as **excellent**. All recent internal and external reviews (including Lehman reviews) indicate that the Division's projects are well managed, and that there are no major issues which need to be addressed.

The project manager interviewed was able to easily articulate how project management is done, which indicates that our systems are well thought out and planned. One statement made was "working within the Technical Division is conducive to managing projects." All the major areas defined in the PMBOK are covered in the methodology used in the Division. This methodology can be rather informal, but this has historically been very effective. The Division is staffed with experienced scientists and engineers, who have a proven track record of successfully completing projects on time and within budget.

Identified opportunities for improvement

It would be helpful to have a documented framework describing how the Division typically manages projects. Currently project managers new to the Division need to learn as they go when it comes to how the Division typically manages projects. The result is satisfactory (i.e. they learn and the projects are successful), however it might be helpful to be able to provide new project managers with a brief framework from which to work.

Schedule for implementation of improvements

The task of putting together a project management framework is very large, and it's costs and benefits will need to be looked at before it is decided to implement. Therefore no schedule has been determined at this time.

Status of improvements from previous assessment

N/A

Attachments (supporting data, worksheets, reports, etc.)

The following documents are included as attachments to this report:

"Audit notes" - Notes documenting the details of the assessment

"PMBOK" - The table of contents for the 2000 version of the PMBOK

"Lehman review" - A portion of the recent Lehman review report

"Project Management Training" - Record of the training received on PM

"US-CMS Project Management Plan" - The PMP for the overall US-CMS project

"Organization Chart - CMS" - The org chart for the US-CMS project

"FY2002 Statement of Work" - SOW for FY2002

"TD Quality Management Program" - The quality program used within the TD

"Organization Chart - TD" - The org chart for the Technical Division

"Quality Assurance Plan" - The QA plan for the TD portion of the US-CMS project.

"FNAL Factory Responsibilities" - Document defining the responsibilities for everyone involved in the TD portion of the CMS project

Audit notes from TD-2002-13 Self-assessment of Project Management:

Background:

In order to make the assessment manageable, I decided to make the scope the TD portion of the US-CMS project. I had just done a QA assessment of the project, and was very familiar with it. This is also a project which is a new model for Technical Division. The Division has extensive experience in managing large HEP projects, but these projects have historically been within Fermilab or within the DoE lab system. The CMS project is a much broader collaboration, and so the work is spread around many different organizations. For example, the L1 manager works here a Fermilab (Dan Green), but the L2 and L3 managers (Gena Mitselmakher and Andrey Korytov respectively) are scientists at the University of Florida. For this project, the TD Factory Manager (Giorgio Apollinari) reports through the L3 manager at UF. From my point of view, this model is something that we will continue to use more and more of. There are very limited resources within HEP, and many organizations which want to participate. This means that we need to adjust our ways of doing business to fit into this model of project management. It is for this reason also that I chose to look at the CMS project for this assessment.

Specifics:

The TD FNAL Factory Manager (Giogio Apollinari) took on this role in August of 1998. Prior to this work he was a project leader within the CDF collaboration (in the Particle Physics Division).

About 1.5 years ago, Giorgio took a 5-day class on project planning, execution and control. He also had a copy of the *Project Management Body of Knowledge* (PMBOK), and so we decided to frame our conversations around the main topics identified in the PMBOK. These notes will generally follow the PMBOK.

Project Scope Management:

Much of the scope of the project was decided prior to Technical Division's involvement, so there was not too much done in this area. The project work breakdown structure (WBS) and the conceptual design (as documented in the Design Report) was defined prior to TD involvement. However, many specifics did need to be defined, and so the TD staff did participate in the detail planning. The TD project team was responsible for creating the detailed design (i.e. translating the conceptual design into a detailed design with approved drawings and specifications). One system which was not in place at the start of the project was a configuration control mechanism. There was a financial and scope change mechanism in place (see the US-CMS Project Management Plan section 8.2). There was not a system in place to handle detailed design changes. The TD Project Engineer defined and implemented a configuration management system for design changes.

Project Time Management

Much of the "big picture" time management was done prior to Technical Division's involvement. However, most of the details regarding the schedules and detailed activities needed to be determined. The TD project team was responsible for fabricating the prototypes, and validating the initial time management planning. In an effort to ensure that the project would remain on schedule with the planned resources, the TD project team conducted detailed studies of the manufacturing process after 30 chambers were completed. These studies resulted in the publication of a document entitled "CMS EMU Chamber Assembly Manpower Analysis." This document defined the durations needed to complete each detailed task, and was used to set the final production timeline. It was the effort that went into creating this document which allowed TD to appropriately plan for the chamber production.

One of the feedback systems within the project is centered around understanding and reporting on the production status. The FNAL Factory Manager has required the panel machining Group Leader to report her panel production status on a weekly basis. The FNAL Factory Manager has also required that the chamber production Group Leader to report his chamber production status on a monthly basis. These data are then reported to the L1 Project Manager so that he knows how the task is progressing.

Project Cost Management:

The cost management for this project is done formally in the Particle Physics Division. The TD FNAL Factory Manager does cost management informally, simply so that he is aware of the status of project finances. This is not optimal, but does appear to be working.

The TD project team did find that the initial cost estimates for resources were quite a bit off, and so much effort went into redefining the cost baseline for the TD portion of the project. Since the redefinition, the project has been operating within budget.

Project Quality Management:

This is one of the areas in which the Division is well suited to manage. We have a full-time quality manager, and have had a formal quality assurance program in place for many years (currently defined in TD policy document TD-2010). The methodology for the project was to use the quality systems already setup within the Division, and tweak them for the project's specific needs. One of the formal documents for the project is the QA plan, which describes the various quality systems used by the project. This area is very well managed and is under good control.

Some specifics in this area are that project reviews are conducted throughout the process, which ensures that quality of design and quality of production are achieved. An Engineering Design Review was held at CERN, and it focused on interfaces. Two Production Readiness Reviews were held in TD, and these focused on design and production. The result is that peer reviews were completed and helped to assure the success of the project.

Project Human Resources Management:

This was an area which the TD FNAL Factory Manager, and his team, needed to do a bit of work in. They were responsible for creating the manufacturing system to fabricate the chambers. This entailed pulling together the various personnel to make this happen. They started by defining a Project Engineer (Nelson Chester), and a production lead person (Glenn Smith). This core team then needed to build a small crew of technicians which would build the chambers. They used the normal personnel channels within the Lab (Laboratory Services Section) and have assembled a very good team of technicians. Based on the results of the recent QA assessment, and the recent Lehman review, they have been very successful in this area. They are producing more good chambers with less personnel than planned, and maintain a very high level of morale.

Project Communications Management:

For the most part, the communications channels in the project are informal, but effective. There are formal channels between the various groups, but most of the communication is done informally through e-mail, phone and in-person conversations. This "free flowing" methodology is conducive to open dialogue, and people feeling they can share concerns and ideas.

The formal communication is centered on project status updates. The TD FNAL Factory Manager gets regular updates from the production lead persons, and then provides overall production status updates to the L1/L2/L3 project leaders.

With the use of the Internet, all project information can be shared very easily. This is advantageous for distributed projects like CMS.

Project Risk Management:

For the most part, risk management on the project was done prior to TD involvement. The TD project team has done some informal risk management in their detail planning, but this done in order to appropriately plan their work. Some risk management was involved during the process of redefining the cost baseline. It was necessary to redefine the areas of risk when asking for more money to complete the project. For example, the risk of bad parts making it to the production floor was weighed against the cost of doing inspections. Data from prior inspections was used to adjust the inspection levels so that the risk and cost benefits could be balanced.

Project Procurement Management:

Similar to quality management, procurement management systems have been formally defined and in use in TD for many years. We maintain a small team of procurement experts to support the work of the Division. For the project, the TD FNAL Factory Manager adopted the overall methodology already in place in the Division.

Summary:

In summary, the project management methodology in use in Technical Division appears to be very effective in ensuring project success. One quote from the TD FNAL Factory Manager was "working within the Technical Division is conducive to managing projects." His experience in another Division helped him to be able to manage this project, but the Technical Division is setup to be able to handle projects of all types and sizes. The track record of successfully managing projects is a result of having systems in place in the Division which are conducive to managing projects.

One area that could be improved upon is in regards to documentation. The TD FNAL Factory Manager had to learn on-the-job how the Division typically manages projects. Since he came to the Division, we have revised and reissued the quality management program, but that is only part of project management. He said that it would be very helpful to have a documented framework in which to work when starting a new project. This framework would not be a set of "do's and don'ts", but instead would define how business is normally done within the Division. It would then be up to each project adopt and adapt the various systems to the specific requirements of the project.

Contents

Close-Out Report

on the

Department of Energy/
National Science Foundation
Review Committee

for the

Technical, Cost, Schedule, and
Management Review

of the

U.S. LHC CMS DETECTOR PROJECT

June 6, 2002

TO: Mr. Daniel Lehman, Director, Construction Management Support Division, SC-81

DATE: April 17, 2002

RE: Request to Conduct a Review of the U.S. ATLAS and U.S. CMS Construction Projects During June 3 - 6, 2002

The Joint Oversight Group (JOG) for the U.S. LHC Program requests that you conduct a review of the U.S. ATLAS and U.S. CMS Construction Projects at Fermilab on June 3-6, 2002.

The charge for this review is to assess:

- Technical progress in each subsystem;
- Schedule progress on completing the U.S. deliverables including installation;
- Revised plans for pre-operations in 2002 - 2004;
- Adequacy of the updated estimated cost to complete; and,
- Status and plans for project contingency budgets.

Please provide a report on the review to this office by July 15, 2002.

Mini-reviews were conducted of the U.S. ATLAS Construction Project in December 2001 and of the U.S. CMS Construction Project in November 2001. The review committees concluded that both projects were making good technical progress and costs were tracking close to plans. There were some concerns with the schedule due to delays in the LHC program as well as delays in some of the U.S. activities.

We appreciate your assistance in this matter. As you know, these reviews are an important element of the Department of Energy/National Science Foundation (DOE/NSF) joint oversight of the U.S. LHC Program and help to ensure that the U.S. meets our commitments on cost and schedule.

[signed]

John R. O'Fallon
Co-chair
U.S. LHC Joint Oversight Group
Department of Energy

[signed]

John W. Lightbody, Jr.
Co-chair
U.S. LHC Joint Oversight Group
National Science Foundation

cc:
James Decker, SC-2
Milton Johnson, SC-3
S. Peter Rosen, SC-20
Glen Crawford, SC-22
Marvin Goldberg, NSF
Thomas B.W. Kirk, BNL
Ken Stanfield, Fermilab
William Willis, Columbia University
Dan Green, Fermilab
Jane Monhart, CH/Fermi Area Office
James Yeck, CH/Fermi Area Office
Pepin Carolan, CH/Fermi Area Office

Department of Energy/National Science Foundation
Review Committee on the U.S. CMS Construction Project

CONTENTS/WRITING ASSIGNMENTS

Ken Johns
Paul Sheldon
Mike Sokoloff

WBS 2.1 Endcap Muon (WBS 1.2)

2.1.1 Findings

We find no major technical risks in the Endcap Muon (EMU) project.

The EMU project is approximately 70% complete. The project BCWP is $26.5M and the ETC is $12.3 M. The assigned contingency on the ETC is 48%, which is adequate for this project. The costs are under control for this project. Over half of the ETC resides in M&S.

The production of CSC panels is nearly complete and CSC assembly is proceeding according to the schedule. Installation of on-chamber electronics and chamber certification at the FAST sites has started slowly but there is comfortable schedule float.

The on-chamber electronics is in production. Some of these electronics are nearly completed while others are just starting. All on-chamber electronics should be available by October, 2003.

The design and prototyping of the peripheral crate electronics seems to be complete. The start of the off-chamber electronics production depends on radiation tests and a beam test in LHC-like beam conditions. This beam test has been postponed by CERN from fall, 2002 until spring, 2003.

CSC installation at SX5 should begin at CERN in November, 2002. It appears above ground installation can proceed quickly. The planned vertical slice tests are critical pre-commissioning tests.

Good progress in developing a robust alignment system was presented. However, the design has not yet converged. The DCOPS development is not finished and will incur schedule risk if not completed by early 2003.

2.1.2 Comments

The EMU group is to be commended for its excellent progress.

The electronics group must ensure that the LHC-like beam test does not jeopardize the completion of the off-chamber electronics. A backup plan should be developed.

The muon group has increased the scope of their deliverables in various ways, but these appear to be beneficial to the success of the EMU detector. Engineering work on the infrastructure at CERN and the vertical slice-tests are examples.

We endorse the re-scoping of the ME3 alignment system.

We were told that detailed M&O plans remain under discussion. It appears at least some of M&O goes to maintaining a standing army.

2.1.3 Recommendations

1. Work with CERN to ensure that the LHC-like beam test has high priority

2. Complete a detailed M&O plan and match personnel to that plan in the next 6 months.

The George Washington University

School of Business and Public Management

certifies that

Giorgio Apollinari

has successfully completed

Project Planning, Analysis, and Control

April 23, 2001 through April 27, 2001

Batavia, IL

and is awarded 2.8 continuing education units

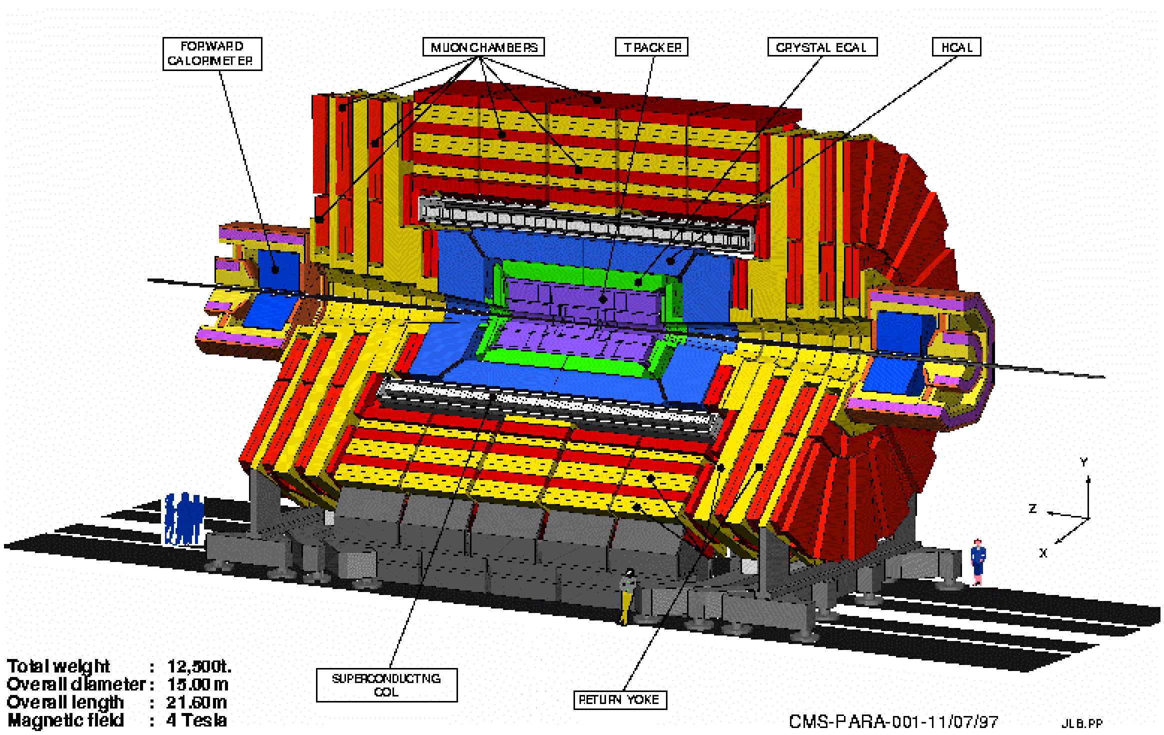
Washington, D.C.

Susan M. Phillips

Susan M. Phillips
Dean, School of Business and Public Management

US CMS
Project Management Plan

November 1998



Submitted, Accepted, and Approved by:

US CMS Project:

D. Green, Technical Manager

E. Temple, Construction Project Manager

Fermilab:

K. Stanfield, Deputy Director

J. Peoples, Director

DOE Fermi Group:

J. Yeck, U.S. LHC Project Manager

A. Mravca, Fermi Group Manager

LHC Program Office:

M. Goldberg, NSF Program Manager

D. Sutter, U.S. LHC Program Manager

Approved by:

DOE NSF Joint Oversight Group

J. O'Fallon, Director
Division of High Energy Physics
Department of Energy

J. Lightbody, Jr., Executive Officer
Physics Division
National Science Foundation

US CMS Project Management Plan

Table of Contents

Section 1

Introduction

1. Introduction

This Project Management Plan sets forth the plans, organization, responsibilities, and systems for managing the work necessary for successful completion of the US Compact Muon Solenoid (CMS) construction project. Fermilab will provide management oversight for this project. This management oversight role is assigned to the Fermilab director, and thence to his designee, the deputy director, for detector and experimental program oversight. The project includes the construction of elements of the CMS detector for which the US groups collaborating on CMS take responsibility. A US CMS Project Office has been formed and has been charged with meeting the technical, cost, and schedule objectives of the US CMS Project. The project has its management office at Fermilab, in Batavia, Illinois. Fermilab is a DOE Laboratory operated under contract DE-AC02-76-CH-03000 by Universities Research Association, Inc. (URA). DOE, NSF, Fermilab, and the US CMS Collaboration will work as a team to accomplish the US CMS Project.

The US CMS Collaboration will participate in building the Compact Muon Solenoid (CMS) experiment, designed to study the collisions of protons on protons at a center of mass energy of 14 TeV at the Large Hadron Collider (LHC) at CERN. To enable studies of rare phenomena at the TeV scale, the LHC is designed to operate at a luminosity of 10^{34} cm^{-2} s^{-1}. The physics program includes the study of electroweak symmetry breaking, investigation of the properties of the top quark, searches for new heavy gauge bosons, probing quark and lepton substructure, looking for supersymmetry, and exploring for other new phenomena.

The US CMS Group agrees to take leadership responsibility in the CMS experiment for the endcap muon system, and for all hadron calorimetry, as well as for associated aspects of the trigger and data acquisition system. The US CMS Collaboration also plans to work on important areas of electromagnetic calorimetry, tracking, and common projects. These common projects will be provided as in-kind contributions whenever possible.

1.1. US CMS Project

The US CMS Collaboration is part of the CMS Collaboration (operating under the CMS Constitution) of high energy physicists from many nations. The CMS detector is designed to exploit the full range of physics at the LHC up to the highest luminosities.

Besides its responsibility noted above, for constructing the endcap muon system and hadron calorimeter system, US CMS groups will also take responsibility for parts of the CMS trigger/data acquisition, electromagnetic calorimeter, and forward pixel tracking. The US will design the endcap steel, which will be constructed as a CMS common project. The hadron calorimetry is managed by US groups. The US groups will build the barrel, supply the endcap transducers and front-end electronics, and build half of the forward system while maintaining complete hadron calorimeter management responsibility. In addition, since the hadron calorimeter is supported by the solenoid cryostat, US groups are involved in the design of the cryostat and intend to construct elements of it as a CMS Common Project.

For the other subsystems, the US responsibilities are not global. However, in every case they are focused on a particular area of US expertise. For example, US groups have overall CMS trigger management responsibility and will furnish essentially all endcap muon level 1 triggers, all calorimeter level 1 triggers, the event builder switch, and the Data Acquisition output filter units. In EM calorimetry, the US CMS is responsible for transducers, front-end electronics, and monitoring. In tracking, the US groups will build all the endcap silicon pixels.

1.2 Project Management

The Project Management Plan presents the top level technical, cost, and schedule baselines for the US CMS Project, and sets forth the organization, systems, and plan by which the project participants will manage the US CMS Project. The line of authority at the top levels of the US CMS Project is shown in Figure 1.1.

The management approach described here is based on Office of Science and NSF experience with projects to construct complex detectors. It incorporates new features designed to address the unique challenges that result from joint agency sponsorship, funding caps, and the scale of the international collaboration. Three fundamental principles underlie the development of the organizational structure, the assignment of roles and responsibilities, and the implementation of management systems to optimize the success of the project. These principles are:

- The US CMS technical director and the construction project manager are jointly appointed by DOE, NSF, and Fermilab with input from the US CMS Collaboration. The US CMS Technical Director has the technical responsibility for the successful achievement of the performance goals while working closely with the Construction Project Manager who has responsibility to complete the project within the cost and schedule objective.
- Relevant formal management systems and requirements are implemented to aid in achieving the project goals and to account properly for the use of public funds. Fermilab has management oversight responsibility for the US CMS Project. To accomplish the oversight function, Fermilab will convene a Project Management Group, which will act as a high-level change control board for the US CMS Project.
- DOE, ER, NSF, Fermilab, and US CMS share the common goal of successfully completing the US CMS project and will openly communicate issues and work jointly to solve problems.

Following this introduction, Section 2 provides an overview of the design goals, scope, and objectives of the US CMS Project. The roles and responsibilities of the major project participants are defined in Section 3. Sections 4 through 7 describe the work and its organization and the associated cost, schedule, and technical baselines. A discussion of the system that will be used to manage and control cost and schedule and to measure the technical performance of the project is given in Section 8. Reporting requirements and review procedures are described in Section 9.

This plan will be reviewed and revised, as required, to reflect new project developments and other agreements among the participants. Revisions, as they are issued, will be signed by all participants, and will supersede in their entirety previous editions. To the extent that there are inconsistencies or conflicts between this plan and the terms and conditions of applicable laws, regulations, and contracts, the provisions of those documents shall prevail over this plan.

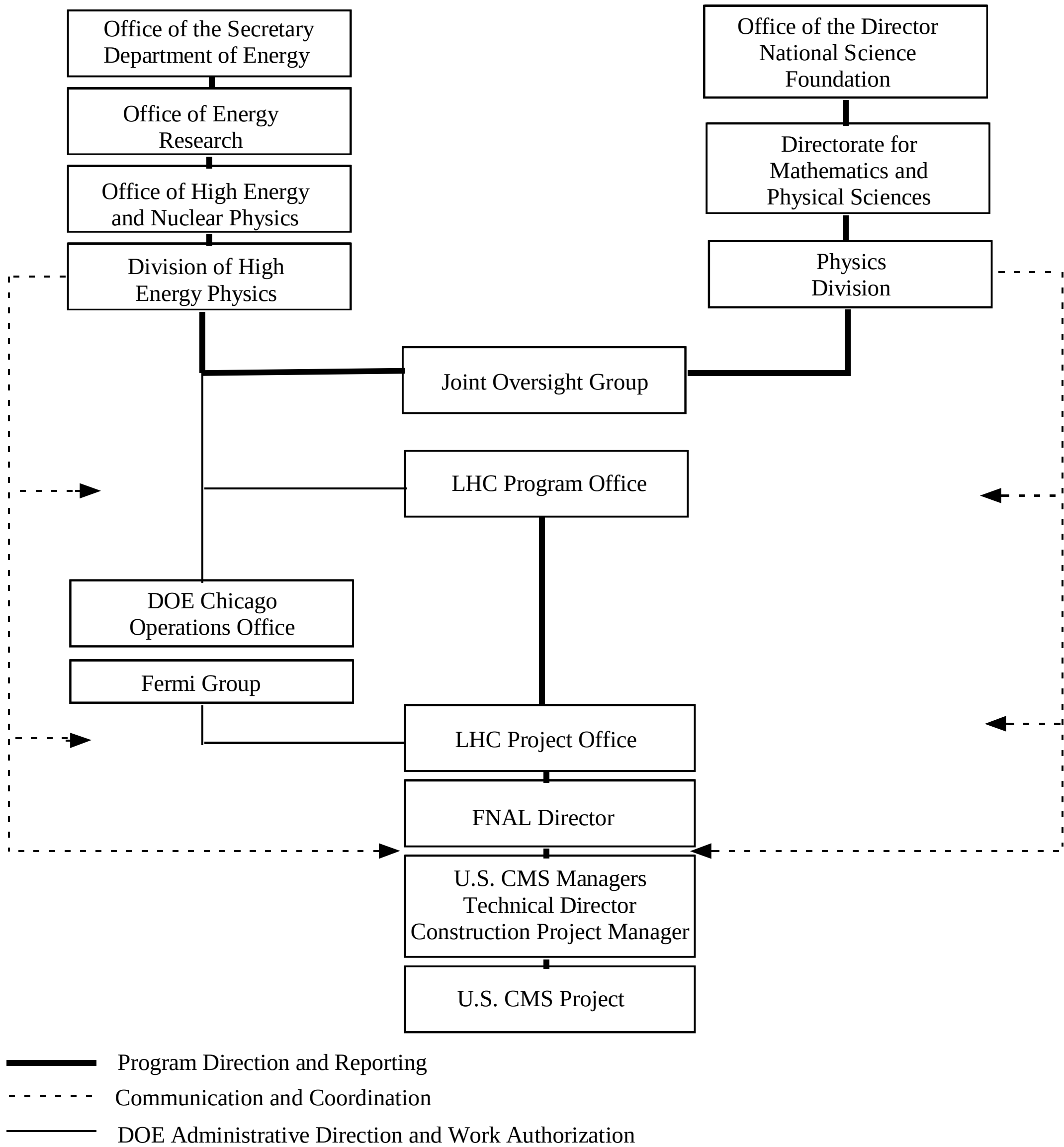


Fig. 1.1: Line of Authority at the Top Levels of the US CMS Project.

Section 2

Project Objectives

2. Project Purpose

2.1 Project Objective

The purpose of the US CMS Project is to construct the elements of the CMS detector for which the US groups collaborating on CMS take responsibility. Successful construction will enable high energy physicists to participate in research at the high energy frontier available at the Large Hadron Collider.

The US CMS project is described in the US CMS Letter of Intent of September 8, 1995 and in the US CMS Project Status Report of October 15, 1996, and is outlined below. US responsibilities within CMS include both management and construction.

US groups have management responsibility for the endcap muon system, the hadron calorimeter, and the trigger. Construction responsibilities within the US extend to portions of all five CMS subsystems: Muon, Hadron Calorimeter, Trigger/DAQ, Electromagnetic Calorimeter, and Tracking. In addition, there is US participation in the Common Projects. The costs of the Project Office at Fermilab are explicitly called out. Hence, there are seven work breakdown structure level 2 categories, as discussed in Section 5.

2.2 Technical Objectives

US CMS responsibilities in the muon system are for construction of the endcap muon chambers. US CMS responsibilities in the hadron calorimeter system are for construction of the entire barrel, the endcap transducers and readout, and roughly half of the forward system – concentrating on transducers and readout. US physicists also have responsibilities within the CMS trigger and data acquisition system. US CMS groups will construct the level 1 calorimeter and endcap muon trigger and the level 2 event builder switch and the output event filter. US CMS responsibilities in electromagnetic calorimeter are to provide some of the transducers, front-end electronics, and monitoring systems. The US groups involved in CMS tracking will provide all the forward pixel disks. A more detailed technical scope baseline is set forth in Appendix 2.

2.3 Schedule Objectives

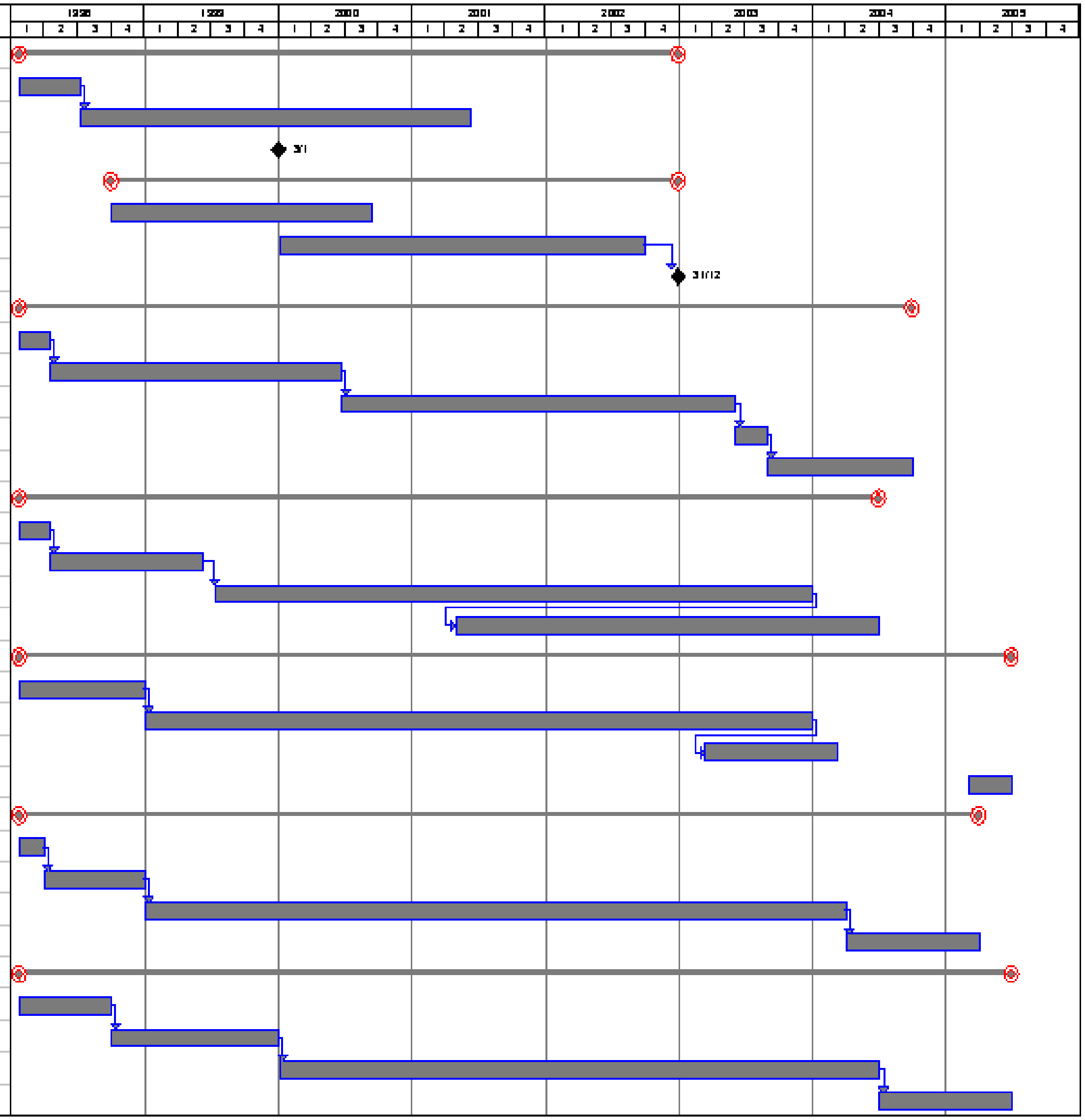
The overall schedule for the project is shown in the CMS Construction Schedule, Fig. 2.1. This schedule must be supported by the US CMS Project schedule in that the US groups are responsible for a subset of the experimental apparatus. Both the U.S. schedule and cost are, of course, dependent on the rate of funding. This schedule results from discussions between CERN, CMS, DOE/NSF, and US CMS. A more detailed schedule is given in Section VI. The schedule is derived from, and is consistent with, the overall CMS planning. The schedule baseline is presented in the form of milestones in Appendix 3.

2.4 Cost Objectives

The Total Project Cost for construction of the US CMS Project is $167.2M in then-year dollars. The cost baseline is presented in Appendix 4: US CMS Cost Baseline. The cost baseline is based on detailed cost and contingency estimates. The technical scope baseline will be completed within the TPC. Should cost performance on the initial technical scope prove favorable, additional items may be added to the scope.

CMS Construction Schedule

ID	Task Name	Start	Finish
1	Civil Engineering	23/1/98	31/12/02
2	Design of buildings	23/1/98	9/7/98
3	Fabication of buildings	10/7/98	7/6/01
4	Surface hall SX, first phase ready	3/1/00	3/1/00
5	Underground	1/10/98	31/12/02
6	first phase	1/10/98	13/9/00
7	second phase	3/1/00	27/9/02
8	hall ready	31/12/02	31/12/02
9	Magnet	23/1/98	30/9/04
10	Design and prototyping	23/1/98	16/4/98
11	Construction	17/4/98	22/6/00
12	Assembly	23/6/00	5/6/03
13	Test	6/6/03	28/6/03
14	Installation	29/6/03	30/9/04
15	Muon System	23/1/98	30/6/04
16	Design and prototyping	23/1/98	16/4/98
17	Preproduction	17/4/98	10/6/99
18	Procurement and production	13/7/99	30/12/03
19	Installation	1/5/01	30/6/04
20	HCAL	23/1/98	30/6/05
21	Preproduction	23/1/98	31/12/98
22	Procurement and production	1/1/99	31/12/03
23	Installation HB/HE	13/3/03	5/3/04
24	Installation HF	1/3/05	30/6/05
25	ECAL	23/1/98	31/3/05
26	Design and prototyping	23/1/98	31/3/98
27	Preproduction	1/4/98	31/12/98
28	Procurement and production	1/1/99	31/3/04
29	Installation	1/4/04	31/3/05
30	Central Tracking System	23/1/98	30/6/05
31	Design and prototyping	23/1/98	30/9/98
32	Preproduction	1/10/98	31/12/99
33	Procurement and production	3/1/00	30/6/04
34	Installation	1/7/04	30/6/05



27 April 1998

Section 3

Project Organization
And
Responsibilities

3. Project Organization and Responsibilities

3.1 Introduction

The US CMS Project operates within the context of the CMS collaboration, an internationally funded experiment located at CERN. The CERN management has ultimate responsibilities for CMS, and CMS reports to it. The executive function in CMS is provided by the CMS Management Board. The CMS Management Board is advised on technical matters by the Technical Board and on financial matters by the Finance Board.

The organization of the full CMS Collaboration is described in the CMS Constitution of September 13, 1996. Within CMS, the US CMS Collaboration acts congruently with a governance described in “The US CMS Constitution,” August, 1997. Copies of these documents reside in the US CMS Project Office Records Repository. The DOE and NSF have jointly negotiated and signed an agreement and protocols with CERN for US participation in construction of the LHC accelerator and in the international collaborations for construction of the ATLAS and CMS detectors that will carry out the LHC scientific program.

Elected representatives of the US CMS Collaboration include a Spokesperson and an Executive Board. These entities represent the US CMS Collaboration in interactions with the formal US CMS Project. As a US Project, US CMS is financially responsible ultimately to DOE and NSF which are, in turn, responsible to the U.S. Congress. The remainder of this chapter focuses on the project aspects of the US CMS project.

3.2 Department of Energy and National Science Foundation (NSF)

Department of Energy and National Science Foundation are the funding agencies for the U.S. CMS Project. As such they monitor technical, schedule, cost, and management performance for the project.

The DOE has delegated responsibility for the U.S. CMS Project to the Office of Science, Division of High Energy Physics. The NSF has delegated responsibility for the U.S. CMS Project to the Division of Physics, Elementary Particle Physics Program. The assigned divisions in DOE and NSF function together through a Joint Oversight Group.

This activity is carried out under the provisions of an International Cooperation Agreement between CERN and DOE/NSF signed on December 19, 1997.

3.3 Joint Oversight Group

The U.S. CMS Project receives funding support from both DOE and NSF. All the subsystems involve close collaboration between DOE and NSF supported groups. It is, therefore, essential that DOE and NSF oversight be closely coordinated. To that end, the DOE Division of High Energy Physics and the NSF Division of Physics have formed a Joint Oversight Group whose responsibilities are defined in a Memorandum of Understanding between DOE and NSF. The Joint Oversight Group will establish programmatic guidance and direction for the U.S. CMS Project, coordinate DOE and NSF policy and procedures, and oversee the project as described in the DOE-NSF Memorandum of Understanding and the U.S. LHC Project Execution Plan.

All documents approved by Joint Oversight Group are subject to the rules and practices of each agency and the signed Agreements and Protocols.

3.4 U.S. LHC Program Office

The LHC Program Office, led by the LHC program manager, will provide day-to-day program management and support for U.S. participation in the LHC. The LHC program manager receives direction from, and reports directly to the Joint Oversight Group. As the DOE has been designated “lead agency” for the U.S. LHC Construction Program, the LHC program manager will generally be a DOE employee appointed by the director of the DOE High Energy Physics Division, subject to the concurrence of the Joint Oversight Group. The associate U.S. LHC program manager will generally be an NSF employee appointed by the director of the NSF Physics Division subject to the concurrence of the Joint Oversight Group. The program manager and associate program manager are responsible for daily coordination of the joint oversight activities described in the MOU between DOE and NSF. They coordinate the needs of the U.S. CMS Project within Headquarters. Specific responsibilities of the U.S. LHC Program Office are defined in the U.S. LHC Project Execution Plan.

3.5 DOE, Chicago Operations Office

The DOE Chicago Operations Office has the contract management responsibility for Fermilab. The CH Fermi Group will be the home of the U.S. LHC project manager. The Fermi Group manager will delegate to the LHC project manager the authority for day-to-day implementation and direction of the project. The Fermi Group manager will provide support from Fermi Group staff when necessary and appropriate.

3.6 U.S. LHC Project Office

The LHC Project Office, led by the LHC project manager, will provide day-to-day DOE/NSF project management and support for the U.S. LHC projects. The LHC Project Office serves as the day-to-day contact for DOE and NSF on issues specific to each of the U.S. LHC Projects. The U.S. LHC Project Manager will be appointed by the Fermi Group Manager, subject to the approval of the Joint Oversight Group. Specific responsibilities of the LHC Project Office include:

- To review and recommend approval of project planning documents including the U.S. LHC Project Execution Plan and its attendant project management plans for each of the three U.S. LHC projects;
- To review and recommend approval of project baselines and evaluate project performance against such baselines;
- To implement procedures for baseline management and control and approve changes to Level 2 baselines and recommend changes or corrective action to Level 1 baselines;
- To approve contingency for the U.S. LHC projects within levels established in the project management plans;
- To define the expectations for the project management systems used by the U.S. LHC projects;
- To conduct regular reviews of the U.S. LHC projects and participate in collaboration reviews as appropriate and needed to carry out on-site management;

- To participate in and provide support for the U.S. LHC Program Office peer reviews and reviews by oversight committees;
- To maintain close contact with the participating universities and national laboratories to assist in expediting the activities of the U.S. LHC projects;
- To ensure compliance by the individual LHC Projects with DOE and NSF requirements, e.g., ES&H and contracting regulations;
- To identify and arbitrate unresolved issues within the individual project organizations;
- To prepare quarterly reports and such other reports on the status of the U.S. LHC projects for DOE and NSF management as required in the Project Execution Plan and applicable DOE and NSF requirements;
- To manage all of the project office documentation;
- To keep DOE and NSF management informed on significant project issues and events.

3.7 Fermilab Director

The Fermilab director has the overall responsibility to the Department of Energy and the National Science Foundation for the management oversight of the US CMS Project. The Fermilab director has delegated certain responsibilities and authorities to the deputy director. Management oversight concerns the scrutiny necessary to maintain the cost and schedule goals to achieve the agreed project scope. The US CMS Collaboration consults with the Director as part of the procedure for appointing the US CMS technical director and construction project manager. The responsibilities of Fermilab are further described in a letter of joint appointment from DOE and NSF to the Fermilab director, dated November 30, 1997.

3.8 Fermilab Deputy Director

The deputy director is responsible for management oversight of the project. The technical director and construction project manager report to the deputy director and he will ensure that their duties carried out effectively. The Fermilab deputy director concurs in the Memorandum of Understanding between CERN and US CMS and in the Memoranda of Understanding between US CMS and the collaborating institutions.

To implement the work plan for the project, Memoranda of Understanding with participating institutions are written assigning responsibilities and describing the work to be executed. The Project Management Plan, the cost estimate, the schedule, and the financial plan for the project require the approval of the Fermilab deputy director and DOE and NSF with the concurrence of CMS and CERN.

3.9 Project Management Group

In response to the Department of Energy’s and the National Science Foundation’s request that Fermilab exercise management oversight for the US CMS detector project, a Project Management Group will be convened by Fermilab. The deputy director chairs the Project Management Group, which meets as necessary to monitor the progress of the project. The Project Management Group will include members from Fermilab, US CMS, and the DOE/NSF Project Manager as an observer. The US CMS spokesperson is also a member of the Project Management Group, thus ensuring communication of scientific issues to the US CMS Collaboration. The Project Management Group also serves as a high level Change Control

Board. The Project Management Group receives the reports of the US CMS construction project manager. As noted above the deputy director chairs the Project Management Group. The deputy director, construction project manager and technical director prepare agendas for these meetings.

Oversight of the project is implemented in part through reviews. Along with providing routine interactions with project management the Project Management Group will identify actions and initiatives to be undertaken to achieve the goals of the project including the allocation of both financial and human resources. The Project Management Group will also function as the Baseline Change Control Board for the project.

3.10 US CMS Level 1 Managers (Technical Director and Construction Project Manager)

The US CMS construction project manager and the US CMS technical director are co-leaders of the US CMS project. As such, they serve as level 1 managers of the US CMS project whose office resides at Fermilab. They have duties, roles, and responsibilities that are distinct, as well as some that are held jointly as described below. The primary focus of the construction project manager is to complete the project within its approved scope, on budget, and on schedule. The primary focus of the technical director is to see to it that the project produces components that meet technical specifications. The technical director and construction project manager consult regularly, keep each other fully informed of actions taken, and serve as each other's deputies in those roles and responsibilities that are distinct. Each backs up the other when either is not available.

3.11 US CMS Technical Director

The US CMS technical director is the principal point of contact for scientific issues and the technical performance of the US CMS scope of work. The technical director ensures that the project's technical goals are appropriate and achieved.

The US CMS technical director provides programmatic and technical coordination for the US collaboration's effort to construct and commission the components for the CMS detector. This is outlined in the Experiments Protocol to the International Cooperation Agreement and specified in an international Memorandum of Understanding agreed to by all the participants involved in supporting the CMS project. The technical director works with CMS to determine the scope of the US CMS contributions to the CMS detector. Scope changes from the baseline follow configuration change control procedures specified in this plan.

The technical director assists in developing the integrated cost and schedule plan for the project and negotiates and approves the Memoranda of Understanding and annual Statements of Work which are based on the plan. These Memoranda of Understanding and annual Statements of Work will be consistent with the project scope described in Appendix 2, US CMS Technical Baseline Document, and with approved changes to this document. The technical director approves the annual budget request made to DOE and NSF, which is prepared by the construction project manager in a manner consistent with the cost and schedule plan. The technical director maintains the level 1 schedule, which interfaces with the CMS general planning.

3.12 US CMS Construction Project Manager

The US CMS construction project manager manages the US collaboration's effort to construct and commission components for the CMS detector, as outlined in the Experiments Protocol to the International Cooperation Agreement and specified in an international Memorandum of Understanding. He is the principal point of contact for all parties on the project management of the US CMS construction effort. The construction project manager is responsible for completing the construction project on schedule and within the approved funding and scope. The construction project manager is responsible for preparing the Project Management Plan and ensuring implementation of the management systems described in that document.

The construction project manager establishes and maintains an effective project organization to manage procurements, construction and commissioning of project components. He is responsible for allocation of resources assigned to the US CMS project. The construction project manager has fiscal authority for US CMS project funds and is responsible for monitoring expenditures of these funds as well as for tracking and reporting variances from baseline scope, schedule and cost estimates specified in the cost and schedule plan. The construction project manager is responsible for developing and presenting DOE and NSF the budget requirements for the project, consistent with the cost and schedule plan. He is also responsible for determining the allocation of the funds available, including contingency funds. The construction project manager has line management responsibility for Environment, Safety and Health for the US CMS project.

The construction project manager will develop an integrated cost and schedule plan and approves the Memoranda of Understanding and annual Statements of Work for the project.

3.13 Roles and Responsibilities of the Construction Project Manager and Technical Director

Either the technical director or the construction project manager may represent the US CMS project in interactions with CERN, DOE, NSF, Fermilab, and the collaborating universities. The technical director and construction project manager report to the director of Fermilab or his designee and through him to DOE and NSF. Both are appointed jointly by DOE, NSF, and Fermilab.

The construction project manager and the technical director each have authority to negotiate on behalf of the US CMS project with collaborating institutions and Fermilab for collaboration or laboratory resources and for their optimal utilization and management.

Either the technical director or the construction project manager may identify the need for project scope changes as they arise. When considering scope changes having significant impact on the physics capability of the detector, the technical director may receive technical advice from review committees. The technical director creates such committees as needed and appoints their members in consultation with the US CMS Executive Board and the CMS Management Board. Section 8 of this document describes the procedures for scope changes.

The technical director and construction project manager are responsible for organizing review presentations and status reports on the project in response to requests from the Fermilab director or the funding agencies. The construction project manager and technical director will initiate internal reviews of level 2 subprojects to ensure that subprojects are meeting technical performance, cost, and schedule milestones.

The construction project manager and technical director have the joint authority to appoint deputy and assistant managers and subproject leaders such as level 2 managers as described below.

3.14 Level 2 Managers

The WBS level 2 managers are appointed jointly by the US CMS technical director and construction project manager. The level 2 managers are members of the Project Management Group. They have specific responsibilities listed below:

- Define the WBS work scope
- Estimate work scope cost
- Schedule the work scope
- Time-phase cost estimate (integrate cost estimate to schedule)
- Determine schedule progress at the end of each month
- Validate earned value monthly for each active task
- Determine/validate monthly actual costs
- Evaluate monthly and cumulative-to-date budgets, earned value, and actual costs
- Accomplish analysis and take corrective action accordingly
- Analyze each month the cost and schedule variances provided by the project office
- Take corrective actions to meet technical, cost, and schedule baselines
- Plan and manage the design, construction, installation, and commissioning of their respective subsystem projects
- Serve as the cost/schedule managers for all WBS elements in their subprojects
- Participate in project planning
- Manage cost estimating for their subsystems
- Participate in project planning, scheduling, and assessing work accomplishments

3.15 Project Cost and Schedule Manager

Project cost and schedule manager reports to the construction project manager and is responsible for the operation of the project management control system including:

- Maintenance of the baseline cost estimate
- Maintenance of the baseline schedule
- Monthly update of project office schedule progress from the level 2 managers
- Monthly collection of project actual costs
- Production of monthly cost performance report

- Analysis of actual cost reports from the participating laboratories for correctness of charges
- Assistance to the project office and level 2 managers in budgeting.

3.16 US CMS Project Office

3.16.1 Fermilab as US CMS Host Institution

Fermilab has agreed to act as host laboratory to the US CMS Project, and will serve as the location of most project reviews. The US CMS Project Office is located at Fermilab, and will provide administration for DOE funds. (Administration of NSF funds is provided by Northeastern University; see below.) Fermilab will also provide Service Accounts for US CMS groups, as well as travel and purchasing support.

Use of Fermilab facilities and services shall be agreed upon via Memorandum of Understanding just as with the use of available infrastructure at any US CMS institution. The level 1 manager's report to the Fermilab deputy director to account for all resources provided by Fermilab to US CMS. The services may include services provided to the Fermilab CMS group or may be services provided to other US CMS institutions. Within the framework of the Memorandum of Understanding, specific items shall be negotiated annually by Fermilab (as host laboratory), by the US CMS technical director and construction project manager, and by the collaborating US CMS institutions. These specific items are incorporated in the annual Statement of Work.

3.16.2 Allocation of Funds

The construction project manager annually determines the allocation of funds to US CMS institutions with advice from the technical director. Subsequently, purchase orders are issued to those institutions (including Fermilab as a US CMS collaborating institution). Explicit arrangements are defined in the US CMS Memorandum of Understanding and annual Statement of Work, which appear in Appendix 1.

The organization of the US CMS Project Office is shown schematically in Fig. 5.1. The US CMS level 1 managers head this office. Allocations of project funds are the purview of the project manager with the scientific advice of technical director. All costs of the Project Office (exclusive of physicist salaries) shall be explicitly borne by the US CMS Project and are called out in the US CMS WBS.

3.16.3 Management Reserve and Funding Allocation

The construction project manager shall hold a management reserve each fiscal year. This management reserve is created by initially allocating amounts that leave sufficient budget authority for additional allocations throughout the year. That reserve will be committed by the construction project manager during the course of the year, based on performance and need of the various groups in the US CMS Collaboration. The reserve will be allocated to individual US CMS institutions in the same manner as the main fiscal year allocation.

3.16.4 Northeastern University

The Northeastern University Administrator of NSF Funds is a member of the Project Management Office of the US CMS Project as indicated in Figure 5.1. The Administrator of NSF Funds is responsible for administration, disbursement, and reporting of the use of NSF funds in accordance with the NSF cooperative agreement with Northeastern University. The Administrator is appointed by the NSF and serves as the NSF liaison on the CMS Finance Board. The Administrator is a member of the Project Management Group.

As a member of the project management team the Northeastern University Administrator of NSF Funds reports to the construction project manager and under his direction the Administrator arranges for the appropriate procurement instrument (e.g. Subcontract) to be issued from Northeastern University to the respective CMS participating institutions. Disbursement and utilization of funds provided by the NSF for US CMS are subject to this management plan and the configuration, change control, and reporting procedures herein defined. The annual Statement of Work describes a workplan for each institution that is consistent with the scope of the US CMS Project approved by the funding agencies. Subcontracts issued by Northeastern will authorize expenditures at the lowest level of the WBS in a manner consistent with the approved Statement of Work for each institution. The NSF funded institutions invoice Northeastern University by WBS activity. Level 1 manager approval is required before invoices are paid. Northeastern University will track procurements and invoice payment and report this information to the US CMS Project Office on a monthly basis.

3.16.5 Project / Collaboration Interactions

The US CMS Project personnel are a subset of the US CMS Collaboration who focus on constructing the US CMS Project scope portions of the CMS detector. As such the life of the project team spans only the construction period. The Collaboration continues during the use of the detector for physics research. Furthermore, the Collaboration arranges for the presentation of talks and papers at conferences and undertakes activities outside the scope of the project, such as offline computing.

As noted above the formal project / collaboration interaction is through the spokesperson and the Executive Board. The spokesperson is a member of the Project Management Group and is therefore well informed of progress and pending changes, so as to assure that scientific issues are communicated to the US CMS Collaboration.

3.16.6 Support and Programmatic Organization

The US CMS Project Office will draw on Fermilab resources as agreed by the Fermilab director. The use of these resources will follow procedures consistent with the Laboratory's current accounting, budgeting, human resources, ES&H, and procurement department policies. The Project will obtain support to the extent agreed from the Laboratory's indirect support group, including:

- Accounting and Budgeting
- Environment, Safety and Health
- Human Resources

- Legal and Material
- Facilities Management
- Quality Assurance
- Information Services

All support functions will be provided through the Laboratory organizational lines of authority and responsibility. The US CMS project manager will direct questions of priority need for Laboratory support through normal lines of authority to the Laboratory deputy director.

3.16.7 Review Committees

Review committees provide a means for the technical director and the construction project manager to review technical, cost, and schedule issues for level 2 subprojects. These committees may also review the physics performance of the subsystem or may recommend scope changes to construction project manager and technical director. Review committees are appointed from the CMS membership as required. The construction project manager and technical director charge them, in consultation with the Project Management Group. Reports and recommendations from review committees are transmitted to the level 2 managers and are in general made available to the entire US CMS collaboration.

3.16.8 Subproject Technical Committees

There may be technical committees associated with a subsystem and separate from the US CMS Review Committees discussed above. The level 2 manager, as needed, appoints them. Members of such technical committees advise the subsystem level 2 managers on technical directions, alternatives, and methods of performance. The members of the committee include scientists responsible for the design and fabrication of the subsystem or of major tasks within it, as well as other technical experts. The level 2 manager appoints the members of subproject technical committees. These committees act in an advisory capacity. Decision authority remains in the hands of the level 2 manager consistent with the line responsibility described above.

3.16.9 Project Communications

The US CMS Project necessarily entails coordination among CERN, Fermilab, DOE, and NSF. At the experiment level, CMS must coordinate with the US CMS collaboration. The US CMS Project involves DOE, NSF, CERN, Fermilab, CMS, and US CMS. For the project to progress, all parties need to be fully informed of current progress, plans, issues, problems, solutions, and achievements.

Communication among participants is free and informal to the maximum extent feasible. Notes, “drafts,” phone calls, electronic mail, and informal discussions are exchanged frequently among the participants to accomplish information flow, raise issues for mutual resolution, and explore the viability of plans and solutions. Distribution of copies of informal correspondence to all participants is desirable to keep them fully apprised of these communications. Each organizational participant should designate an individual to coordinate informal communications and to assure their proper distribution within that organization.

The World Wide Web is proving a valuable tool in providing up to date information to members of the collaboration and others. The web home pages for CMS and US CMS are http://cmsinfo.cern.ch/Welcome.html and http://uscms.fnal.gov respectively.

3.16.10 Educational Outreach

The education liaison function includes the development of educational proposals of US CMS. In support of these and other educational activities, the US CMS Project Office supplies funds for programmatic travel and for material and service supplies. A CMS Educational Outreach Person has been named. This person works with personnel from other laboratories and institutions to maximize the effectiveness of the educational outreach program.

Section 4

Work Plan

4. Work Plan

4.1 Introduction

The US CMS detector activities are briefly described in sections 2.1 and 2.2. The technical scope baseline is described in more detail in Appendix 2. This section describes the work plan for accomplishing the tasks required to provide the deliverables described in the technical scope baseline at CERN for incorporation into the CMS Detector.

4.2 Work Description

This project provides for the construction of elements of an experiment to be performed at CERN, designated the US CMS Project. This effort entails completion of a research and development program, conceptual design, detailed engineering and design, procurement of materials and services, fabrication of sub-detector elements, testing of components, assembly of components into sub-detectors, and installation of sub-detectors into the experimental cavern and assembly of the entire detector in the cavern.

The US CMS Project Organization described in section 3 of this document will carry out or oversee these activities. The research and development program was carried out primarily in FY 96 and 97. Technical design reports have been written and approved for six of the seven sub-detector elements included in the US CMS scope. A list of the major procurement items (costing more than $100K) has been compiled and includes the planned schedule for these acquisitions shown in Appendix 6. Staffing requirements at each of the participating institutions have been projected based on the agreed-upon scopes of work that they will perform.

4.3 Quality Assurance Program

Quality assurance is an integral part of the design, procurement, fabrication, and construction phases of the US CMS Project. Special attention is being devoted to items that will affect the performance capability and operation of the CMS detectors. The responsible person for technical specifications is the US CMS technical director.

It is the policy of the US CMS project that all activities shall be performed at a level of quality appropriate to achieving the technical, cost, and schedule objectives of the project. To implement this policy, the US CMS project will develop a standard quality implementation plan based on the quality assurance criteria established by DOE and NSF. The responsible person for the Quality Assurance Plan for the US CMS is the US CMS Construction Project Manager.

The US CMS project will follow a Specialty Quality Implementation Plan that will define the management policies in regard to 1) quality assurance program, 2) personnel training and qualification, 3) quality improvement, 4) documents and records, 5) work processes, 6) design, 7) procurement, 8) inspection and acceptance testing, 9) management assessment, and 10) independent verification.

Vendors will implement quality assurance programs appropriate to the services being furnished. As specified in the Memorandum of Understanding, US CMS activities at each institution will use the implemented quality assurance programs. All these programs, as well as implementing procedures, are subject to review and audit by the US CMS Project Office at Fermilab.

4.4 Environment, Safety, and Health (ES&H)

Activities conducted at US institutions will follow the ES&H policies and procedures of those specific institutions. The annual Statements of Work signed between the institution and US CMS identify a responsible safety person for CMS activities at each institution.

Two large activities are taking place at Fermilab: construction of the endcap muon chambers and construction of the hadron calorimeter scintillating tile sandwiches. The muon chambers will follow the ES&H procedures of the Technical Division. The calorimeter sandwiches are being put together by the same group that recently completed the CDF end plug calorimeter and will carry on the CMS activities using the same Fermilab procedures used for CDF.

Finally, these components are being delivered to CERN to be incorporated in the CMS detector there. Therefore our designs will take into account the CERN safety specifications, procedures, and guidelines. Furthermore, CERN safety personnel including the CMS Group Leader in Matters of Safety and a member of Technical Inspection and Safety (TIS) commission will participate in critical (technical) design reviews of those items being provided by US CMS that have important safety ramifications. Appropriate TIS personnel approve the safety aspects of the designs.

Section 5

Work Breakdown Structure

5. Work Breakdown Structure

All work required for successful completion of the US CMS Project is organized into a work breakdown structure. The work breakdown structure contains a complete definition of the scope of the project and forms the basis for planning, execution, and control of the US CMS project. The US CMS work breakdown structure is extended to a sufficiently low level to make each deliverable and its provider unique and trackable. Specifically, the work breakdown structure provides the framework for cost estimating, scheduling, and budgeting.

The project summary work breakdown structure is a consolidation of the top three levels of the US CMS construction project work breakdown structure. The sample US CMS construction project work breakdown structure is as follows:

1	**Endcap Muon**
1.1	Cathode Strip Chambers
1.2	Electronics
1.3	Mechanical Structure
1.4	Installation
1.5	Slow Control
1.6	Services
1.7	Alignment
2	**Hadron Calorimeter**
2.1	Barrel Hadron Calorimeter
2.2	Outer Barrel Calorimeter
2.3	Endcap Hadron Calorimeter
2.4	Forward Calorimeter
3	**Trigger and Data Acquisition**
3.1	Trigger
3.2	Data Acquisition
4	**Electromagnetic Calorimeter**
4.1	Barrel Photodetectors
4.2	Electronics
4.3	Monitor
4.4	Crystal Development
5	**Forward Pixels**
5.1	Readout System
5.2	Sensors
5.3	Mechanical and Cooling
5.4	Final Assembly and Testing
5.5	Tests
5.6	Software

5.7 Project Management
5.8 Installation at LHC

6 Common Projects
6.1 Package A, Barrel Yoke and Vac Tank
6.2 Package B, Endcap Yoke
6.3 Package C, Superconductor
6.4 Package D, Coil Winding
6.5 Package E, CERN-Power, He Refrig, etc.
6.6 Package F, In Kind
6.7 Package G, Common Funds
6.8 Common Project Software

7 Project Office
7.1 Baselining
7.2 Tracking
7.3 Reporting
7.4 PO Support
7.5 NEU Administration
7.6 Programmatic Travel
7.7 Education

The levels of the work breakdown structure reflect the logical breakdown of the work required to complete the project. Lower levels provide greater detail. The number of levels is established by extending the description down to a level at which individual components (typically costing about $10k) can be identified and associated into a well-defined piece of equipment or structure.

The detailed activities to design, build, and commission the US CMS are described in the work breakdown structure dictionary and/or in the basis of estimates. Each element of the work breakdown structure has cost, manpower, and schedule associated with it and is the key element for planning and controlling cost and schedule.

Changes to parameters are controlled by a change control system. The impact of any such change on the associated cost, schedule, and WBS dictionary will be evaluated by the appropriate Change Control Board. The cost and schedule manager is responsible for maintaining the current cost, schedule, and dictionary, and the records of all changes. All changes must be approved at the appropriate level before implementation. Once approved, the changes will be incorporated in the work breakdown structure, work breakdown structure dictionary, baseline budget, estimate to complete, schedule, etc. as required.

5.1 Cost Estimating

The work breakdown structure supports a systematic approach to preparing the cost estimate for the project. The work breakdown structure is extended to a sufficient level of detail to allow definition of individual components for which a cost can be reasonably estimated. The budget and cost estimate are equal for the lowest level in each branch of the work breakdown structure when the baseline is approved.

5.2 Scheduling

The work breakdown structure also supports a systematic approach to preparing the project schedule. Again, each work breakdown structure element at the lowest level of the structure is assigned a duration. Establishing the interdependencies between the various elements creates the project schedule.

5.3 Budgeting

The schedule is then "resource loaded" by spreading the cost estimate over time to reflect the work plan. This provides each element of the work breakdown structure at the lowest level a budgeted "cost of work scheduled". The budget of the project can be seen at any level by performing a summary over contributing lower levels. Budgets are formal statements of the financial resources set aside for carrying out specific activities in a given period. Note:

- The budget reflects the US CMS financial plan, which represents the goals of the project management plan.
- The budget is expressed in time-phased quantifiable or measurable terms so that status along the way can be determined.
- All Level 2 components of the organization will be made aware of their portion of the overall budget.
- Performance against the budgets will be monitored and reviewed monthly with project management.

5.4 Work Breakdown Structure Support Requirements and Dictionary

The work breakdown structure, in conjunction with the associated resource-loaded schedule provides the framework for projecting funding and manpower requirements over the life of the project. The work breakdown structure level 2 managers are shown in Table 5.1. The level 2 managers are required to provide the construction project manager a detailed work breakdown structure dictionary of their subsystems. This dictionary and the basis of estimate provide the documentation, which defines the quality of the estimated costs for the project.

5.5 Performance Measurement

The work breakdown structure supports the monitoring, control, and reporting of cost and schedule performance. Since each element of the work breakdown structure, and by association each work element, has a well-defined budget and schedule, a view of the progress of the project at any level is available at any time. Comparison of the actual costs ("actual costs of work performed") and planned budget with the work performed, known as earned value ("budgeted cost of work performed"), provides the cost and schedule variances for current month, cumulative to date, and at completion.

5.6 Management Review, Corrective Actions, and Change Request

The detailed scope of the project is contained within the work breakdown structure and described in the work breakdown structure dictionary. After reviewing the status of their budget/actuals versus work accomplished to date, managers may need to take corrective actions (i.e., descoping work, issuing contingency, etc.) to keep on an acceptable budget and scheduling path. Proposed changes to the scope can readily be evaluated within the WBS framework.

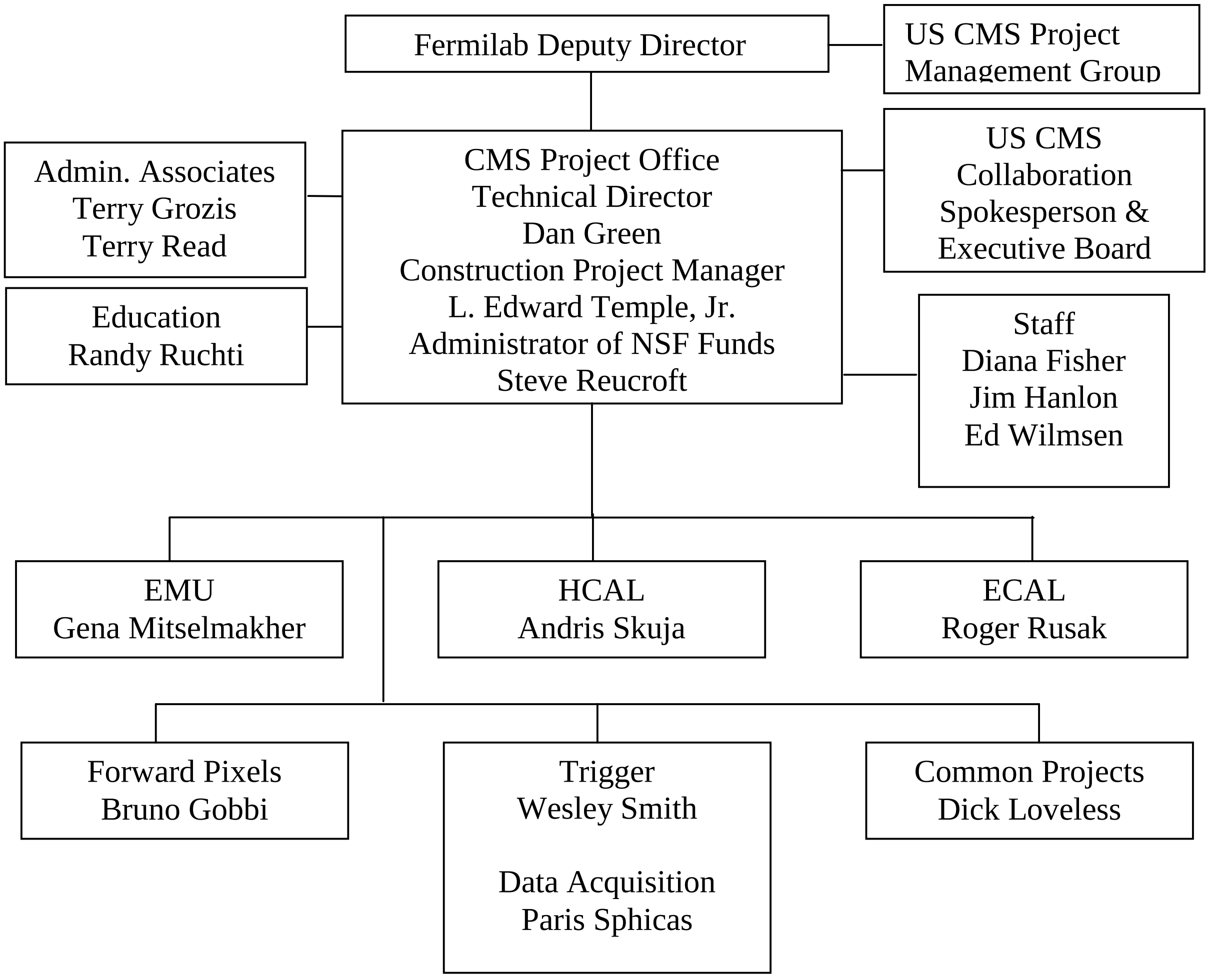


Fig. 5.1: US CMS Project and WBS Level 2 Managers

Section 6

Project Schedule and Milestones

6. Project Schedule and Milestones

6.1 Schedule Baseline

The CMS construction schedule provides the master schedule for construction. The schedule baseline sets forth the major activities, decision points, and activity interfaces essential for completion of the US CMS Project. The baseline schedule includes interpretation and optimization of activities related to the design, procurement, fabrication, assembly, testing, installation, and checkout of detector elements. A master schedule will be developed to include major activities and decision points. It is composed of major work breakdown structure level 3 elements including significant milestones. This schedule will be the top-level project schedule and is the basis for baseline development in all lower-level schedules.

Work package schedules at the lowest work breakdown structure level 7 will be assembled into an interconnected activity logic diagram by integrating construction activities within each respective work breakdown structure element. Schedule interfaces with other work breakdown structure elements will be made. This integrated schedule provides a total project critical path. Summarization of these lower-level activities allows status to be rolled up through the various WBS levels to provide intermediate-level and master-level working schedules. These working schedule dates are compared to the established baseline dates, and any variances are addressed in progress reports. Consistency of data from work packages through intermediate schedules to the master schedule will be traced through control and event milestones. All milestones contained in the project master schedule are reflected in the lower-level schedules.

The schedule management and monitoring system will be developed using Microsoft Project, a software tool available at Fermilab and one adopted by CMS. The schedule status is summarized at the various work breakdown structure levels to provide project schedule reporting at the master, intermediate, and detailed levels by work breakdown structure and across functional organizations. The master-schedule will also include a critical path, defined by the construction project manager by considering the critical paths of each of the level 2 efforts.

6.2 Baseline Milestones

A set of project milestones for the level 1 schedule has been defined by the US CMS Collaboration, in consultation with CMS. The level 1 schedule for US CMS and the corresponding CMS milestones appear in the CMS Memorandum of Understanding. The level 2 managers provide subsystem schedules, which are then linked to the level 1 milestones. This linked US CMS schedule is then resource loaded to provide a US CMS cost profile.

A list of controlled milestones that constitute the schedule baseline for change control purposes is given in Appendix 3.

Section 7

Cost and Labor Estimates

7. Cost and Labor Estimates

7.1 Cost Baseline

The cost baseline will be established when it is approved by the Joint Oversight Group. The project cost baseline is equal to the sum of the budgeted costs for each element of the Work Breakdown Structure described in Section 5. Changes in cost, technical requirements, schedules, and plans are to be treated as variances to the baseline.

Based on the DOE/NSF baseline review, the total project cost for the US CMS Project is $167,250K including $14,508K for escalation and $6,920K for R&D. This total should not be exceeded. The US CMS Project cost in FY 1997 dollars is $152,742K. Included in the cost are procurement, assembly, and installation of all technical components, engineering design, inspection, and project management required to assure successful completion of the project. Contingency funds equal to 43% of the base cost, excluding common projects, are also included.

7.2 Obligations and Cost Plans in FY 1997 Dollars

The original construction cost estimate was prepared in fixed-year (FY 1997) dollars. The construction cost in FY 1997 dollars is $145,756K.

7.3 Escalation

Escalation rates are based on an assumed annual escalation rate given by guidance from DOE.

7.4 Budget Authority and Funding Profile

The project baseline schedule, obligations, and cost plan will be based on the best estimate of the funding profile. The obligation plan will be derived from the baseline schedule and cost plans given in this project management plan. Similarly, application of the escalation rates given in Section 7.3 above will result in the cost plan.

7.5 Labor Requirements

Labor requirements have been estimated for each work package in the US CMS Project. These estimates include the required engineering, design, inspection, and acceptance and Fermilab-based project management, as well as manufacturing labor.

Section 8

Project Management System

8. US CMS Project Management System

8.1 Introduction

The CMS Project uses the work breakdown structure described in Chapter 5 as a framework for preparing a detailed cost estimate and a resource-loaded schedule. The work breakdown structure dictionary provides the initial input for the technical scope baseline given in Appendix 2. The time phasing of the resource-loaded schedule has been adjusted to fit within the anticipated funding profile. This then forms the basis for the cost baseline or budget shown in Appendix 4. This system is described in more detail in a US CMS project office procedure.

8.2 Change Control, Change Authorization and Contingency Management

The US CMS Fermilab construction project manager and technical director will control changes in requirements, cost, and schedule (in consultation and agreement, as appropriate, with the US CMS project management group). Any change that affects the interaction between detector subsystems or that significantly affect the performance, schedule, or the safety of the detector must also be referred to the CMS Management Board by the construction project manager and technical director.

DOE and NSF will make funds available for support of the US CMS Project on an annual basis. Each year the construction project manager and technical director review, negotiate, and approve the Statement of Work which will include a description of the work to be performed, the requested funds, and the manpower to be assigned to that year's activities. Also, through reviews, the projected cost of the work, and the currently projected contingency requirement at work breakdown structure level 3 over the life of the project will be known. Funds will then be released to the institutions that are part of the US CMS Collaboration. A management reserve will be held by the construction project manager and will be applied during the fiscal year on the basis of performance and need, following the principles of change control outlined below.

The Project Management Group, chaired by the Fermilab deputy director, will act as a high level Change Control Board for the US CMS Project. The Project Management Group will have as its purview assignment of contingency funds, changes of the scope of the project, and changes to the schedule exceeding thresholds shown in Appendix 6. Scope reductions may be required should projected costs of any level 2 subsystem greatly exceed the budgets to complete.

Formal change requests will be submitted and dispositioned (either approved or disapproved) for all changes exceeding thresholds stated in Appendix 6. The Project Office will maintain a record of all change requests. A *de minimus* level for cost changes is set at $1,000.

The principles of contingency management that the US CMS Project will follow are as follows:

- The cost estimate for each level 2 subsystem will include a contingency estimate based on an assessment of uncertainties and risks associated with the budgeted cost.
- Actual expenditure of contingency will be reflected in a revised estimate at completion, updated at least annually.

The Fermilab US CMS Project Management Group will consider and approve or disapprove all change requests that trigger the threshold set in Appendix 6. The US CMS Project Office will maintain a log of such approved (at any level) change requests. This log will be available for review by all project management.

- All cost changes to the baseline costs shall be traceable.
- The construction project manager must approve in advance all procurements requiring the use of contingency.

Section 9

Reporting and Review

9. Reporting and Review

Tracking and reporting hinges around a monthly status report comprising a technical progress report and a cost performance report. The latter is a monthly report, used by the US CMS Project Office and level 2 managers in the following format at various levels of the work breakdown structure. The report is used to monitor and assess status at a given time and provide information for current period, cumulative to date, and at completion. For example:

SAMPLE FORMAT OF THE US CMS COST PERFORMANCE REPORT

		MONTHLY					CUMULATIVE					AT COMPLETION		
DESC.	WBS	BCWS	BCWP	ACWP	SV	CV	BCWS	BCWP	ACWP	SV	CV	BAC	EAC	VAC
EMU	1.1	$6	$5	$5	($1)	$0	$60	$55	$50	($5)	$5	$241	$241	$0
HCAL	1.2	$8	$9	$7	$1	$2	$80	$90	$70	$10	$20	$276	$276	$0
TRIG	1.3.1	$3	$3	$3	$0	$0	$25	$25	$30	$0	($5)	$620	$620	$0
DAQ	1.3.2	$2	$3	$2	$1	$1	$20	$21	$19	$1	$2	$477	$477	$0
ECAL	1.4	$5	$6	$5	$1	$1	$50	$55	$45	$5	$10	$715	$715	$0
FPIX	1.5	$9	$8	$7	($1)	$1	$15	$16	$10	$1	$6	$167	$167	$0
CP	1.6	$5	$5	$6	$0	($1)	$50	$50	$55	$0	($5)	$230	$230	$0
PO	1.7	$6	$6	$5	$0	$1	$58	$58	$50	$0	$8	$574	$574	$0
TOTAL	CMS	$44	$45	$40	$1	$5	$358	$370	$329	$12	$41	$3,300	$3,300	$0

The monthly reports to the agency project manager will be at level 2. Internal reports can be prepared at any level desired (e.g. level 3 and/or 4 for primary hardware or extremely high-risk items). The US CMS project will collect costs at the lowest level reasonable. Summary reporting at work breakdown structure level 2 or even level 3 is adequate because any time a variance threshold is penetrated, the CMS Project Office must describe what is happening. This will be required under variance analysis reporting for cumulative to date and at completion periods. The reporting is passed to the construction project manager and the Project Office, which is responsible for tracking all US CMS funds. Each institution will provide monthly financial information to the construction project manager in a specified format, which provides cost and schedule variance analysis information. Each level 2 manager will provide monthly reports on technical progress to the construction project manager and the technical director.

Tracking and reporting and the record of performance will form the basis for continuing annual authorization of funds. Authorization to a particular institution is performed by the construction project manager. This is accomplished with the scientific advice of the technical director. This is completed within the framework of the US CMS Memorandum of Understanding and annual Statement of Work.

The US CMS Project reports cost, labor, schedule, and performance data to the Fermilab deputy director and the agency project manager. The objective of the reporting and review activity is to provide for the collection and integration of essential technical, cost, schedule, and performance progress data into the reports and reviews needed for managing and monitoring the US CMS Project. The following paragraphs describe the status and technical reports that will be provided. They also address regular meetings and reviews.

9.1 Meeting and Reviews

9.1.1 Internal US CMS Meetings

Weekly meetings will be held between the construction project manager and technical director and the level 2 managers to discuss progress, problems, and focus resources as appropriate.

Monthly meetings will be held between the construction project manager and technical director and each level 2 manager using the monthly report as a point of departure for reviewing and assessing progress and problems and discussing and agreeing on proper courses of action.

The US CMS construction project manager, technical director and level 2 managers will meet regularly with the US CMS Executive Committee to assess the current status of the project, management issues, and proposed major changes. Communication with the US CMS Collaboration at large is done at the biennial US CMS full-collaboration meetings.

9.1.2 Meetings with Fermilab as Host Laboratory

Regular meetings of the Project Management Group will be held. The US CMS construction project manager and the level 2 managers will review current status of project work, discuss outstanding issues, and update previously identified action items. The agency project manager will be an observer at Project Management Group meetings.

9.1.3 Meetings with DOE and NSF

Weekly Meetings

A weekly meeting will be held between the construction project manager and the agency project manager.

DOE/NSF Sponsored Reviews

DOE and NSF will conduct comprehensive reviews of the technical, management, cost, and schedule of the project. It is expected that these reviews will be conducted at least annually and that status reviews will be conducted every six months. In preparation for the annual reviews, the construction project manager will direct an annual cost-to-complete analysis, based on experience to date.

Appendix 1: Memorandum of Understanding

Memoranda of Understanding will exist both within the CMS collaboration as a whole, and for the US CMS collaboration.

A Memorandum of Understanding is negotiated between CERN as the host laboratory, the collaborating CMS institutions (represented by the CMS Collaboration Board) and their funding agencies (DOE and NSF in the US). A draft of an Interim Memorandum of Understanding covering the initial phase of the CMS experiment has been signed for the 1996 and 1997 period of R&D.

Within the US CMS Project, a US Memorandum of Understanding will be executed. Draft versions of this Memorandum of Understanding and of the annual Statement of Work have been written, and appear here as Appendixes A and B. The signatories of this Memorandum of Understanding are threefold: Fermilab as host laboratory, the US CMS collaborating institution, and the US CMS construction project manager. By means of the Memorandum of Understanding agreement, the level 2 managers and the US CMS project manager will identify the work to be done at each member institution of US CMS, together with the necessary resources. It will also establish reporting to be done by each institution of both financial and schedule milestones.

DRAFT

Memorandum of Understanding
Between

<Institution>

and

US CMS Collaboration
Project Management
At Fermilab

<date signed>

Introduction

This Memorandum of Understanding describes the collaboration by members of <Institution> in the Compact Muon Solenoid (CMS) Project in the United States. The purpose of this collaboration is the design, fabrication, operation, and scientific exploitation of the CMS Detector. The detector is described in the CMS Technical Proposal, (December 15, 1994), the Technical Design Reports, and subsequent technical documents elaborating that design. The contribution of the US CMS Collaboration to the CMS Detector Project is defined by the scope of work set out in the US CMS work breakdown structure and accepted as the baseline set of deliverables by DOE and NSF. This scope of work forms the basis of the Memorandum of Understanding between CERN and DOE/NSF.

The US CMS project management infrastructure (US CMS Project Office) resides at Fermilab, and the responsibility for US CMS project management resides in the US CMS technical director and construction project manager, who report to the US CMS Fermilab Project Management Group and the Fermilab deputy director. The US CMS technical director/ construction project manager have appointed level 2 managers who are responsible to them for subsystems of the US CMS project.

This Memorandum of Understanding describes the long-term contributions of <Institution> to the design, construction, and operation of the CMS Detector. It is understood that these contributions of <Institution> may later be modified or that additional responsibilities may be added. The US CMS project finishes at the end of FY2004.

An annual Statement of Work will detail the contributions of <Institution> as the detector construction proceeds and will contain the specific activities, deliverables and funding required. The normal period of performance will be the US fiscal year (October 1-September 30). A separate Statement of Work will be written for each level 2 subsystem, while the Memorandum of Understanding will be a single document for each US CMS institution. In FY98 Statements of Work were written with all institutions then participating in the project.

This Memorandum of Understanding is made between <Institution>, the US CMS technical director/construction project manager and Fermilab as part of its role in management oversight. It does not constitute a legal contractual obligation on the part of any of the parties. It reflects an arrangement that is currently satisfactory to the parties involved. The parties agree to negotiate amendments to this memorandum as required to meet the evolving requirements of the CMS detector construction program.

Personnel

2.1 List of Scientific Personnel

Participating scientists committed to CMS over the full project period are listed below. No support for these individuals comes from project funds.

Name	CMS Fraction*	Other Research Commitments/Comments

*Time devoted to CMS over and above the indicated CMS research fraction is considered to be <Institution> service effort in support of CMS.

2.2 Collaboration Board Representative

<Name> is the present representative of <Institution> to the US CMS Collaboration Board.

2.3 List of Technical Personnel

Participating technical personnel with the anticipated fraction of their time (time fractions are estimates and are not cost shares) committed to CMS during this period of performance and their source(s) of support are indicated below. The possible sources are DUS = DOE. US CMS Project: NUS = NSF. US CMS Project: DBG = DOE base grant; NBG = NSF base grant. UID = university infrastructure. DOE-supported group; and UIN = university infrastructure. NSF-supported group as shown in the WBS.

Engineers

Name	CMS Fraction*	Cost on CMS Project	Source of Support

Designers

Name	CMS Fraction*	Cost on CMS Project	Source of Support

Technical Specialists

Name	CMS Fraction*	Cost on CMS Project	Source of Support

Programmers

Name	CMS Fraction*	Cost on CMS Project	Source of Support

Others

Name	CMS Fraction*	Cost on CMS Project	Source of Support

2.4 Other Key Personnel

The Environment, Safety and Health officer for <Institution> currently responsible for compliance with applicable ES&H policies associated with CMS participation by this institution is <ES&H Name> of <Institution>. The quality assurance officer for the US CMS group at <Institution> currently responsible.

<Institution> responsible for quality assurance compliance of tasks performed by this institution is currently <name> of <Institution>. [Persons identified in this section are typically ES&H and quality assurance professionals who provide assistance to line personnel responsible for CMS activities.]

3 Design, Fabrication and Installation Responsibilities

3.1 Design and Fabrication Responsibilities – Construction Period

3.1.1 Work Breakdown Structure Items at Level 2. Estimated Cost and Deliverables

The US CMS Work Breakdown Structure contains a detailed cost estimate of the items needed to complete the US CMS project. By this Memorandum of Understanding <Institution> agrees to make a best effort to provide the following items at a cost not to exceed the work breakdown structure base cost estimate. Procedures to be followed in the event of a necessary variation of cost from the base cost are described in Section 3.3 below. The table below lists the work breakdown structure summary items at level 2. Appendix A gives the full work breakdown structure of the items to level 7.

WBS (L2)	Task – Deliverable	WBS Base Cost	Cost at this Inst.	FNAL MPO	DOE Suppl.	NSF
Total	Requested Project funds ($k)	---				

3.1.2 Transportation

Unless specifically indicated otherwise here, items produced by <Institution> for use in the CMS detector or subsystems shall be transported by the providing institution to the agreed upon point of delivery. <Institution> shall be responsible for safe transport of all items to these delivery points. The method of transport and packaging are to be authorized by the US CMS project office in consultation with the appropriate level 2 lead engineer.

3.1.3 Installation and Commissioning

<Institution> will participate in the installation and commissioning of their contributed items at CERN as listed. The <Institution> will also participate in the maintenance and operation of these items.

<Item 1>

<Item 2> . . .

3.2 Coordination and Reporting

The US CMS level 2 manager for the <subsystem> subsystem is <name 1>. This institution contact person for <subsystem> activities at <Institution> is <name 2>. The task managers for <subsystem> activities carried out at <Institution> are as follows

Task	Task Manager

The progress of the design, fabrication, and testing of these components will be reported by the above-named task managers on a monthly basis, by work breakdown structure element to level 3 in detail, to the US CMS level 2 manager, who in turn will report subsystem progress to the US CMS technical director/construction project manager. The technical director/ construction project manager will, in turn, report to the Fermilab project management group.

Technical reporting to CMS project management will be performed by the US CMS Subsystem Coordinator. Financial reporting to CMS will be made by the US CMS construction project manager.

The authorized financial officer at <Institution> is <name>. The US CMS technical director/ construction project manager delegate expenditure authority regarding the designated work breakdown structure items in the Statement of Work to the authorized financial officer subject to the following requirements. The base cost of the work breakdown structure items is given in Section 3.1.1 without contingency. The officer agrees that these cost ceilings cannot be exceeded without the authorization of the technical director/ construction project manager and the relevant level 2 manager. In addition, the officer agrees that item purchases exceeding the delegated limit (currently 10 k$) must be authorized by the US CMS level 2 manager.

Major procurements (currently 100 k$) must in addition have the written authorization of the US CMS technical director/ construction project manager. Items purchased as CMS Common Project items (work breakdown structure category 6) must be explicitly authorized by the US CMS technical director/construction project manager and approved by the CMS Finance Board Chair, regardless of the cost. Items purchased for Project Office (work breakdown structure category 7) must be authorized by the technical director/ construction project manager.

3.3 Reporting to US CMS Project Management

<Institution> will report all CMS related expenditures and labor charges together with associated technical progress in each item of work by Work Breakdown Structure category (Level 7) on a monthly basis through the appropriate US level 2 manager(s) to the US CMS technical director/construction project manager. Cost reporting will apply to US CMS Project funds related to detector fabrication. Other, non-DOE and non-NSF costs will be reported in a manner that is agreed to by the level 2 manager(s), the US technical director/construction project manager and <Institution>. Any request for variance from the base cost must be immediately reported to the appropriate level 2 manager.

Technical progress will be reported by WBS element level 4 to the level 2 manager and the technical director/construction project manager on a monthly basis and will cover all items covered in this Statement of Work regardless of the specific nature of the funding support.

The <Institution> agrees to furnish complete documentation of the quality control and performance checks that are carried out for US CMS. Further, the institution agrees to furnish full documentation of all equipment and services that it provides for the US CMS project. This will include engineering drawings of equipment, full schematics of electronics, and documentation of all software. Where relevant, an acceptable level of spares (~10 percent) will be provided and maintained by the institution.

Each US CMS group at <Institution> agrees, with this document, to set up and maintain a ledger, of a form specified by the US CMS Project Management. This ledger will contain information on cost items at level 7 of the US CMS work breakdown structure. Each Institution agrees to provide and maintain this ledger so as to provide timely information to the level 2 manager and the US CMS technical director/construction project manager.

3.4 Collaboration with Other Groups and Institutions

Design, construction and installation related to the <subsystem> subsystem will be carried out in close communication and collaboration with other groups working on this and related subsystems.

WBS / Task (L4)	Collab. Group	Responsibility with <Institution>

4. Contribution of Effort, Services and Equipment

4.1 Effort

Subject to funding by DOE or NSF, <Institution> will provide support for the scientific and technical personnel as indicated in Section 2. This contribution refers only to support provided outside the US CMS Project.

4.2 Services

The services of the <Institution> Purchasing, Expediting, and Receiving Departments and the Administrative Staff will be available to the CMS project to the degree required to carry out the fabrication responsibilities of <Institution>. By this Memorandum of Understanding, <Institution> agrees to provide the services of the responsible financial officer.

4.3 Facilities and Equipment

The following <Institution> facilities and equipment will be made available to the CMS project to the degree necessary to carry out the design and fabrication responsibilities of the group:

Facilities and Equipment:

4.4 Operating Costs

<Institution>, subject to the availability of funds from DOE or NSF, will support the normal research operating expenses (such as physicists' salaries, travel expenses, miscellaneous supplies, administrative support, etc.) of the <Institution> group working on the CMS project. These normal operating expenses are not considered as part of the CMS detector cost estimate nor will they be borne by the US CMS project.

5. Fermilab (as host institution) Effort, Services, and Facilities

Tracking of Fermilab CMS support, whether provided by Fermilab or paid by the US CMS Project, will be done using appropriate effort reporting codes. The costs incurred will be reported to the Fermilab director.

Subject to agreement, to be negotiated annually with the Fermilab director, <Institution> expects the following Fermilab resources to be available in support of <Institution's> design, fabrication, and installation responsibilities:

5.1 Administrative and Technical Personnel

Participating Fermilab staff members foreseen to be available to the project are:

Administrative Staff

Name	CMS Fraction	Source of Support

Engineers

Name	CMS Fraction	Source of Support

Designers

Name	CMS Fraction	Source of Support

Technical Specialists

Name	CMS Fraction	Source of Support

Programmers

Name	CMS Fraction	Source of Support

Others

Name	CMS Fraction	Source of Support

Administrative and technical staff salary support may be paid by the US CMS Project, or may be provided by Fermilab as project host. The salary support of Fermilab staff contributing to <Institution's> responsibilities must be negotiated annually with the Fermilab director as part of the Statement of Work. Support provided by Fermilab will be tracked and reported to the Fermilab director and the project management group.

5.2 Services

The services of the Fermilab Purchasing, Expediting, and Receiving Departments are expected to be available to <Institution> for the procurement of the following items:

<Item 1>

<Item 2> . . .

5.3 Facilities and Equipment

<Institution> expects that the following Fermilab facilities, equipment, and laboratory space will be available during the course of the project:

Facilities, equipment, and laboratory space:

Costs and Funding

6.1 Expected Sources of Funding

The cost of the detector elements covered under the US CMS WBS are taken in detail from the current US CMS Cost Estimate (<Date>). DOE (NSF) Funds indicate the project funds expected to be provided over the lifetime of the project. <Institution> agrees not to exceed the costs shown above, estimated cost less contingency, subject to the procedures given in Section 3.3.

6.2 Management Reserve

Each year, a Statement of Work will be written with each US CMS Institution for each level 2 subsystem that is relevant. The allocation of funds for the fiscal year will be in two parts. The first will cover work for the first six months. The remaining funds needed to complete the tasks described in the Statement of Work will be provided subject to availability of funding and performance during the first half year. Management control requires the review and concurrence of the level 2 manager and the technical director/construction project manager, as needed, for major expenditures, as defined above. The release of funds above the given thresholds by the responsible financial officer as named above will be contingent upon this concurrence.

Method of Funding Transfers

The expenditures by <Institution> are to be covered by funds provided by DOE or NSF, upon the allocation decision of the US CMS technical director/construction project manager with the concurrence of the US CMS Fermilab project management group.

Funds to cover work or expenditures described in this document may be provided directly to <Institution> by DOE or NSF, or by subcontract from the US CMS Project Office at Fermilab. The choice of funding method shall be at the option of the technical director/construction project manager.

All equipment items bought or fabricated using DOE or NSF funds will be properly marked as the property of DOE or NSF. Any other equipment furnished by <Institution>, as part of the detector will remain <Institution> property. In either case, the equipment will remain part of the CMS detector until it is dismantled or the detector element in question is replaced.

General Considerations

8.1 Safety and Engineering Practices

The experimenters from <Institution> agree to familiarize themselves with DOE and NSF safety policies and to adhere to them. All detector components must be designed, fabricated, installed and operated in conformity with DOE, NSF, and CERN safety policies and practices as well as DOE, NSF, and CERN engineering standards. All engineering, design, quality assurance, safety, and other activities shall be in compliance with International Organization for Standardization standards. All major components will undergo appropriate design, safety, and engineering reviews.

8.2 Operations

<Institution> agrees to maintain, to the best of their ability, equipment provided for the CMS detector as long as <Institution> is a member of the CMS collaboration.

Schedules and Milestones

<Institution> will make every effort to carry out their institutional responsibilities consistent with the schedule for the fabrication of the CMS detector. These schedules may have to be changed as the project progresses. Changes that affect <Institution> will be noted in the annual Statement of Work. The program milestones over the life of the project relevant to <Institution> are listed here:

Program Milestones	Baseline Milestone Date	Current Milestone Date

Makers and Concurrence

The following persons concur in the terms of this Memorandum of Understanding. These terms will be updated as appropriate in Amendments to this Memorandum.

Makers of this Memorandum:

Dan Green US CMS Technical Director	date	Administrative Officer <title> <Institution>	date
Ed Temple US CMS Construction Project Manager	date	<Name> Grants/Contracts Officer <Institution>	date
<Name> US L2 Manager <Subsystem> Subsystem	date	Principal Investigator <Name> <Institution>	date
<Name> US L2 Manager <Subsystem> Subsystem	date	Principal Investigator <Name> <Institution>	date
<Name> US L2 Manager <Subsystem> Subsystem	date	Principal Investigator <Name> <Institution>	date
<Name> US L2 Manager <Subsystem> Subsystem	date	Principal Investigator <Name> <Institution>	date

Concurrence:

Ken Stanfield Deputy Director Fermilab	date	<Name>	date

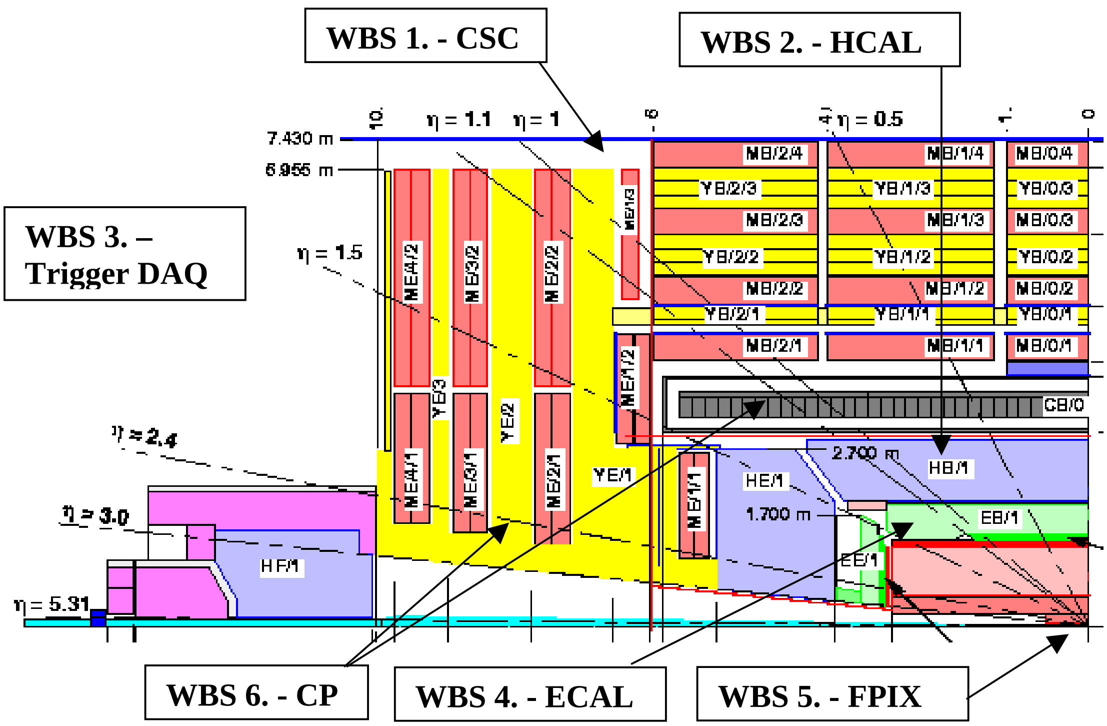
Copy sent to:

Alain Herve CMS Technical Coordinator Fermilab	date

Appendix 2: US CMS Technical Baseline Document

The US CMS Collaboration has agreed to take leadership responsibility in the CMS experiment for the endcap muon system, all the hadron calorimetry, and associated aspects of the trigger and data acquisition system. The Collaboration also plans to contribute to important areas of the electromagnetic calorimetry, tracking, and common projects. The general layout of the CMS Detector is shown in Figure 1.

A summary description of the US CMS baseline scope is provided below. The details at the lowest work breakdown structure level are available in the US CMS work breakdown structure dictionary dated May 19, 1998. Level 2 WBS numbers associated with the various subdetector or subsystems efforts are identified in Figure 1.



1. Endcap Muon – cathode strip chambers
2. Hadron Calorimeter – full HB, HOB, He, and HF transducers and readout – HE scint, HF QP fibers
3. Endcap Muon and Calorimeter Trigger. DAQ filter
4. Electromagnetic Calorimeter – barrel transducers, front end electronics, and laser monitor
5. Forward Pixels
6. Common Projects – endcap yoke and barrel cryostat
7. Project Office

Figure 1

WBS 1.1 – Endcap Muon System (EMU):

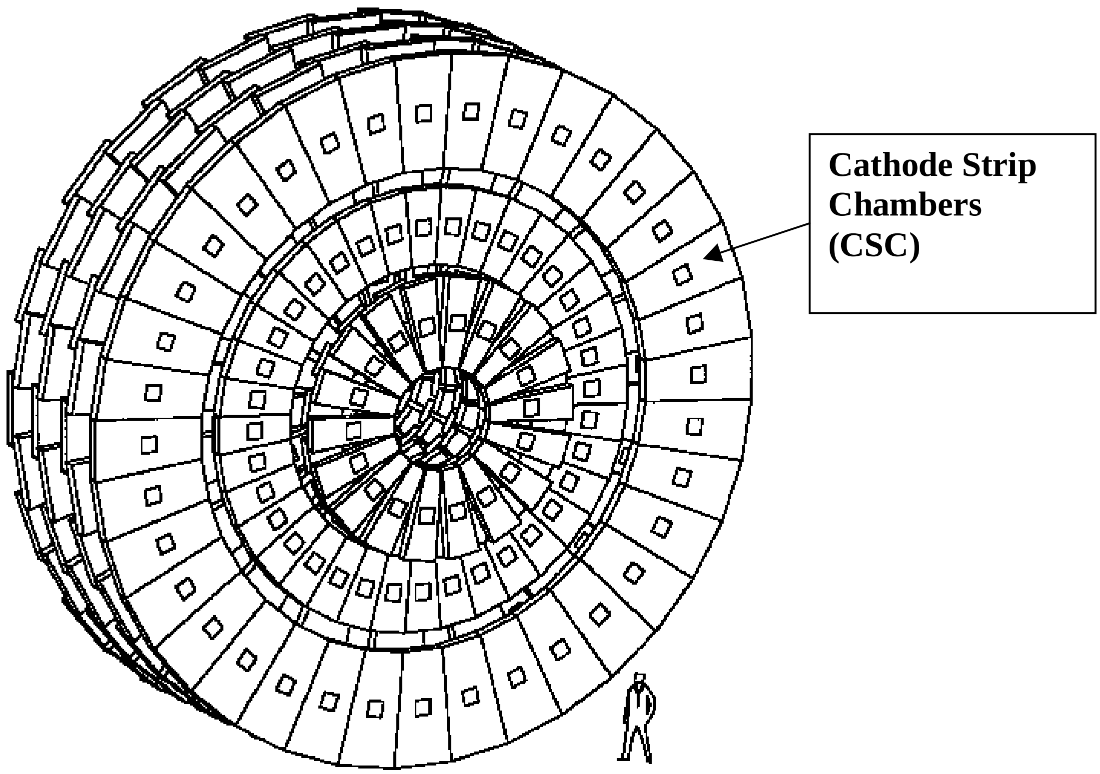


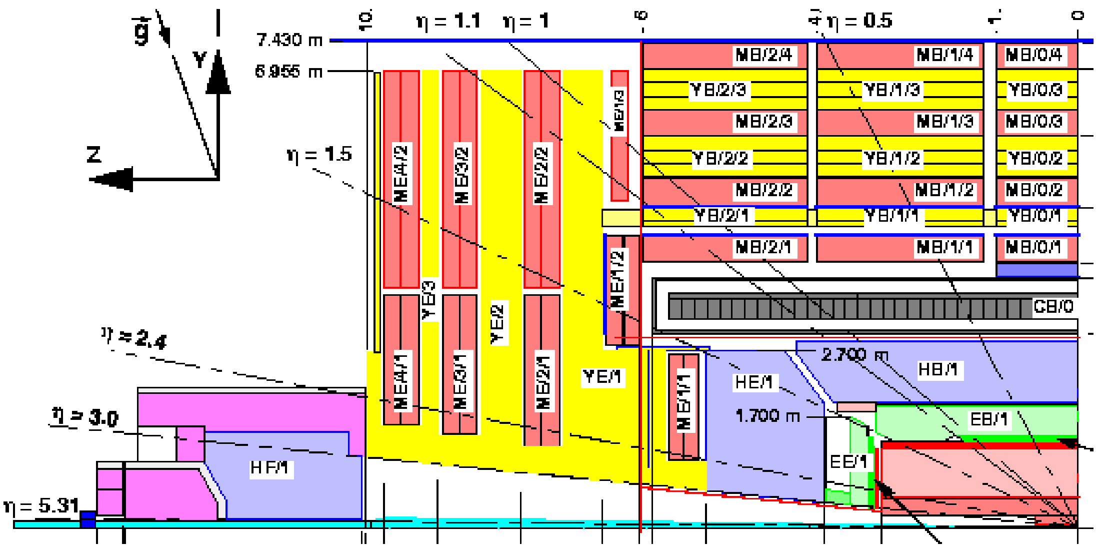
Figure 2

The CMS Endcap Muon System consists of three muon stations (four stations are shown in Figure 2; the fourth station was eliminated as part of the US CMS rescoping exercise) interleaved with three iron disks. The angular region covered is $0.9 < \eta < 2.4$. Here η is the pseudorapidity, that is $-\ln[\tan(\vartheta/2)]$, where ϑ is the angle to the beam axis. Muon stations are six-plane trapezoidal cathode strip chambers. A precise coordinate measurement in cathode strip chambers comes from interpolating charges induced by cathode strips.

The total number of chambers in the endcap system for the US CMS baseline is 360 (372), where the number in parentheses includes spares. The largest cathode strip chambers are 3.4 x 1.5 m^2 in size. Each chamber consists of six trapezoidal planes. Strips run radially to provide a precise measurement of the ϕ coordinate, while wires run azimuthally and define the radial coordinate of the track. The overall area covered by the chambers is more than 950 m^2 and the total number of wires exceeds 1.7 million.

The US will manufacture, instrument, and install 148 large chambers, and will make parts kits for the assembly of 148 smaller chambers by China, and 76 smaller chambers by Russia. The US is responsible for all parts, critical tooling, the on-chamber electronics, and the level 1 trigger.

There are 5 types of chambers shown schematically in Figure 3.



ME23/2 – largest chambers, 10-degree in ϕ, outer ring of stations 2, 3
ME2/1 - inner ring of station 2, 20-degrees in ϕ
ME3/1 - inner ring of station 3, 20-degrees in ϕ
ME1/2 - intermediate ring of station 1, 10-degrees in ϕ (high resolution CSC)
ME1/3 - outer ring of station 1, 10-degrees in ϕ

Figure 3

The ME23/2 are entirely the responsibility of the US.

For ME234/1 the US provides parts and critical assembly tooling. PNPI (Russia) is responsible for assembly, testing, shipping, and commissioning. For ME1/23 the US provides parts and critical assembly tooling. IHEP (China) is responsible for assembly, testing, shipping, and commissioning.

WBS 1.2 – Hadron Calorimeter (HCAL):

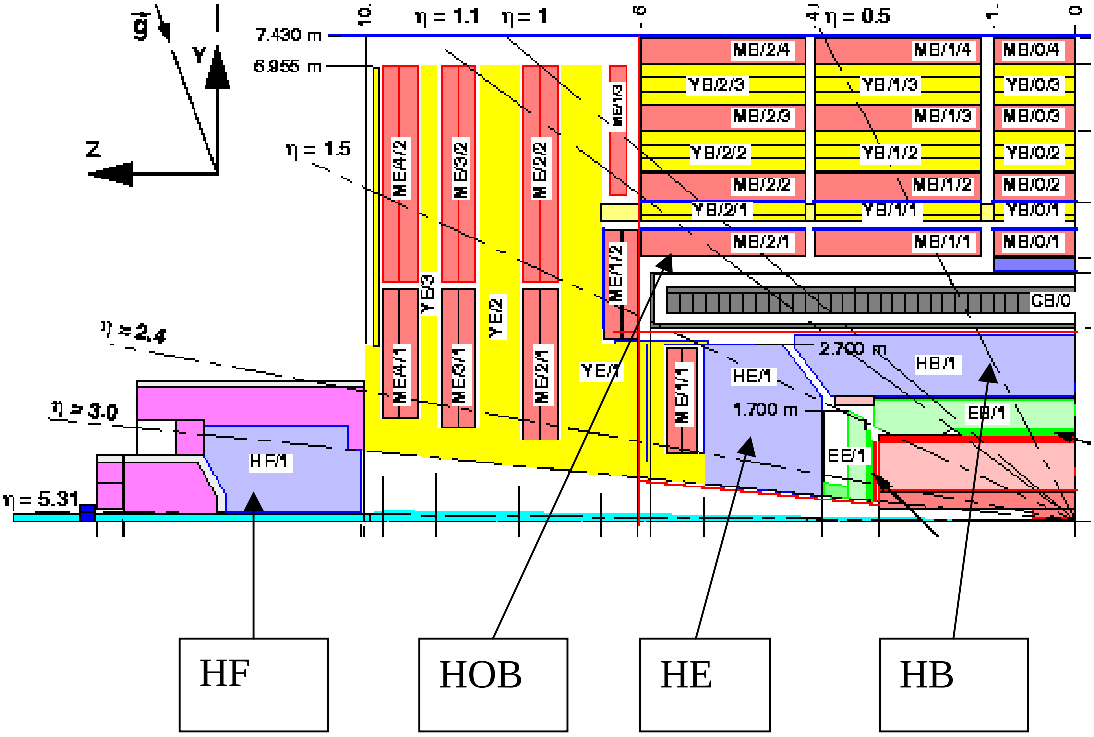


Figure 4

The hadron calorimeter, shown schematically in Figure 4, in CMS is organized geographically. There are five mechanically distinct structures: the barrel (HB, $0. < \eta < 1.3$), 2 endcaps (HE, $1.3 < \eta < 3$), and the 2 forward (HF, $3 < \eta < 5$) calorimeters. The US CMS hadron calorimeter group responsibilities are to produce the barrel absorber and the barrel scintillator tile/wave length shifter optics. In HF the US will supply none of the absorber, but a fraction of the quartz fiber sampling medium. In addition, the US will produce the barrel, outer barrel, endcap, and forward transducers and front end electronics.

The hadron calorimeter is organized into towers of size $\Delta\eta\Delta\phi = 0.087 \times 0.087$ for the barrel and endcap and $\Delta\eta\Delta\phi = 0.174 \times 0.174$ for the forward calorimeter. There are 3 longitudinal depth segments H1, H2, and HO in HB. In HE there are two depth segments, while HF has three; HFE, HFH, and HFT.

The work breakdown structure 1.2 items include all the effort to design, produce, assemble, install, and commission the hadron calorimeter for the CMS detector. The HB calorimeter is constructed of 36 wedges, each weighing ~ 26 tonnes. The absorber is copper for HB and HE. The minimum HCAL depth is 5.8 interaction lengths inside the CMS coil. The HE is built as a single unit, but the optical system is packaged as 18 distinct 20-degree "pie" wedges, thus matching the HB segmentation.

There are distinct calorimeter towers in $\Delta\eta\Delta\phi$ and in longitudinal depth. These are supplied with electronics channels, which amplify and digitize the signals produced by the HPD (HB, HOB, HE), and read out the PMT (HF). The channel count (excluding spares) is 5184 in HB, 2160 in HOB, 3774 in HE, and 1728 (1920) in HF. The resulting digital signals are stored in a pipeline and sent to the trigger/DAQ system by means of multiplexed fiber optic communication systems. The received data is sent to the trigger and DAQ systems separately. The system is calibrated using LEDs, radioactive sources, and lasers.

WBS 1.3 – Trigger/Data Acquisition (TRIDAS):

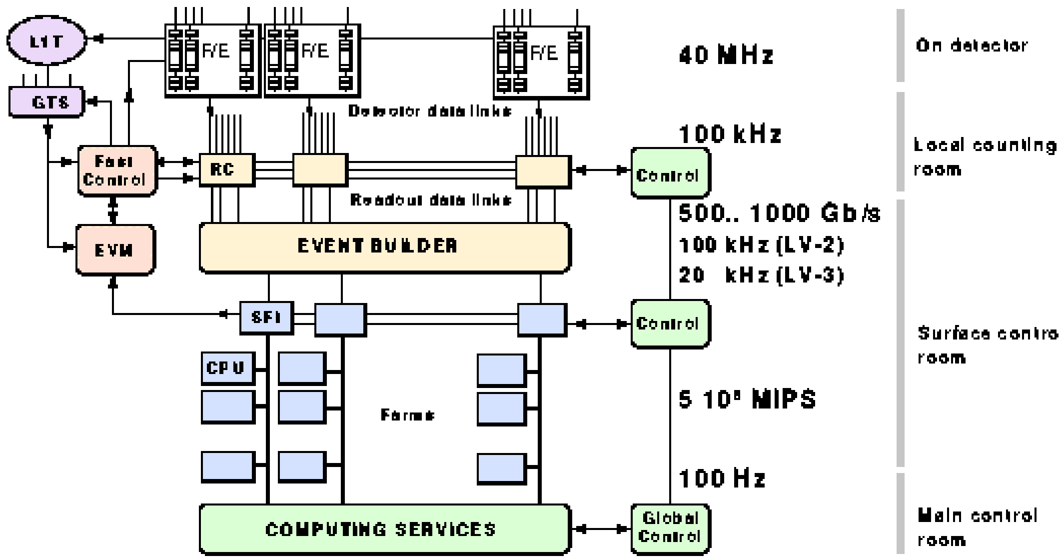


Figure 5

US CMS is responsible for elements of the first level muon trigger and the level 1 calorimeter trigger. In addition, US CMS takes responsibility for the data acquisition filter units (FU), and the event manager (the layout of the data acquisition system is shown in Figure 5).

WBS element 1.3.1.1 includes all the effort to develop, produce, assemble, install, and commission the Regional Muon Trigger. The system is designed with 3 muon stations; however, the design allows easy expansion to a 4-station system. The US will provide Port Cards (55), Sector Receiver Cards (56), and Sector Processor cards (30) for the level 1 CMS Muon Trigger.

Work breakdown structure element 1.3.1.2 includes all the effort to develop, produce, assemble, install, and commission the Regional Calorimeter Trigger. This system processes the electromagnetic and hadronic trigger tower sums from the calorimeter front end electronics and delivers regional information on electrons, photons, jets, and partial energy sums to the global calorimeter level 1 trigger system. The system begins after the data from the front end electronics is received on optical fibers and translated to signals on copper and ends with cables that transmit the results to the calorimeter global level 1 trigger system. The trigger is based on a

54 x 72 (η x ϕ) array of ECAL and HCAL trigger towers. The towers supply 8 bits of energy information. The US provides 22 VME crates with custom backplanes.

Work breakdown structure element 1.3.2 includes all the effort to develop, produce, and assemble the parts of the CMS Data Acquisition system for which the US CMS groups are responsible. The US has undertaken the responsibility to provide the full Filter Unit system and the complete Event Manager system. In the R&D phase, US groups will also participate in the design and testing of prototyping modules that can be used both on the Readout Units and the 432 Filter Units. The complete DAQ system will perform at 75 kHz, and the system is scalable.

WBS 1.4 – Electromagnetic Calorimeter (ECAL):

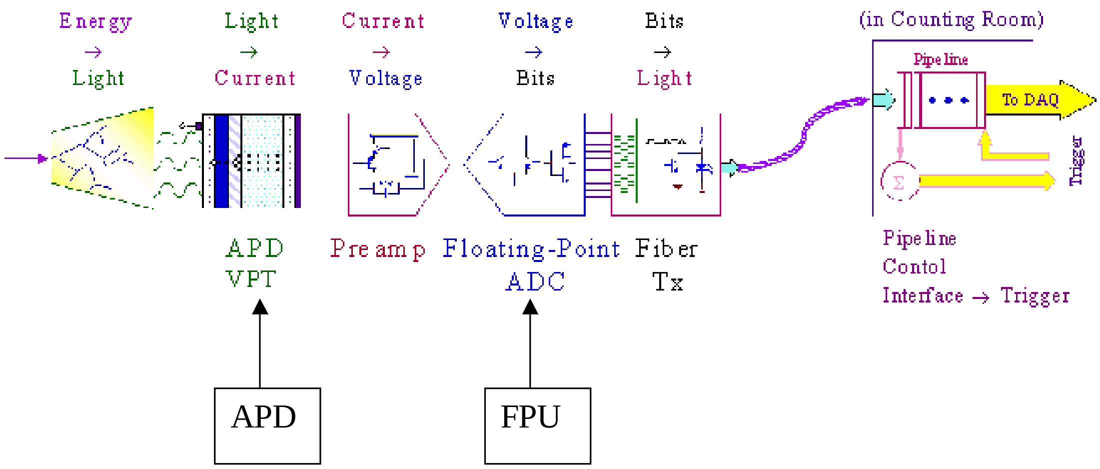


Figure 6

US CMS is responsible for elements (identified in Figure 6) of the electromagnetic calorimeter. This device utilizes $PbWO_4$ crystals to detect electromagnetic showers. The US is responsible for partial procurement, 36000, of the light transducer Avalanche Photodiode (APD), the floating point unit (FPU), 60200, which converts a voltage to a digital number, the bit serializer which converts that number into a serial bit stream for transmission off the detector, and elements of the laser monitor/calibration system.

There are 61,200 crystals in the barrel ECAL, or EB. Each has a pair of APDs with 25 mm^2 sensitive area. The US is responsible for ~50% of the APD prototypes and ~30% of the procurement of the production APDs.

The US is responsible for the design and procurement of all the EB front-end multi-ranging floating point units (FPU), and CHFET bit-serializers.

The US is responsible for elements of the laser monitor system. These include the laser, cooling, collimators, shutters, mirrors, and other optical mounts.

WBS 1.5 – Forward Pixel Tracking (FPIX):

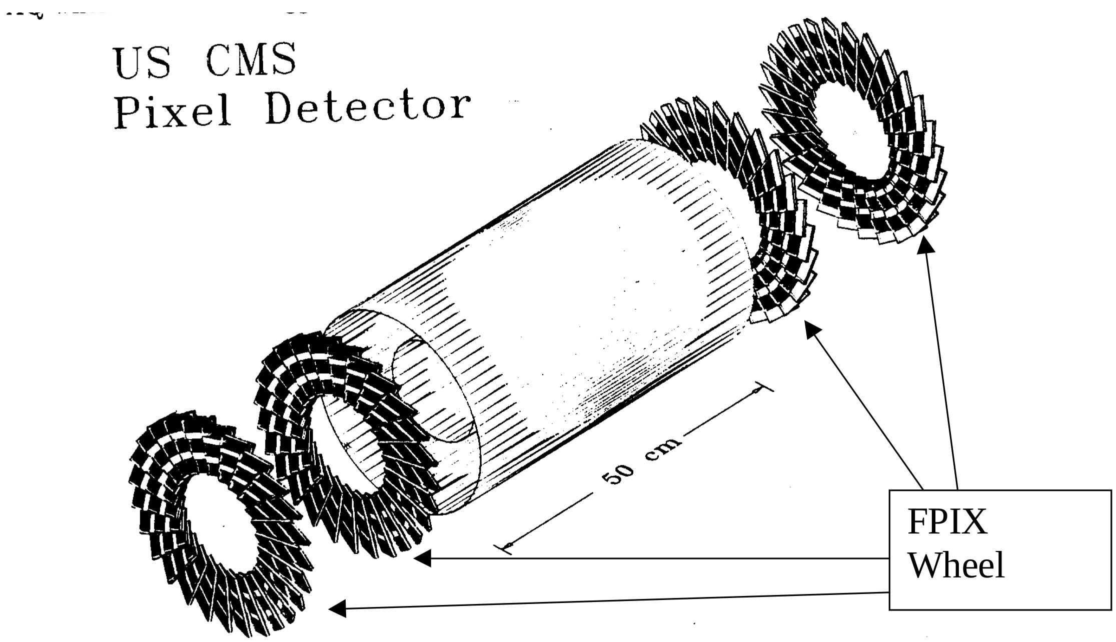


Figure 7

US CMS is responsible for the delivery of the forward silicon pixel (FPIX) detector system. This system consists of 4 assemblies, or wheels, (shown in Figure 7) of silicon pixels. These wheels are made from subassemblies, which are arranged as “turbine blades”. This unique arrangement allows for Lorentz force charge sharing among pixels, thus enabling the devices to have good impact point resolution in 2 dimensions.

The FPIX system covers the angular range $1.4 < \eta < 2.6$. The US will design, assemble, deliver, install, and commission the entire system. This system consists of 4 disks containing 96 “blades”. Each blade has 7 silicon sensor arrays comprising 45 readout chips. There are 4320 total readout chips and 672 Si sensors. The total system has ~12 million pixels, each 150 μm x 150 μm. The system consists of sensors, readout, mechanical support, and ancillary services.

WBS 1.6 – Common Projects:

Common Projects in CMS are the magnet and the common software and computing. The US pays a representative share of the Common Projects as defined to be a fixed fraction of the contribution of the US to CMS. The US contribution will be defined to be the M&S items of the baseline scope of the US CMS project. The fraction is currently assessed to be 31.5 percent. This currently agreed upon US contribution to Common Projects is $23M.

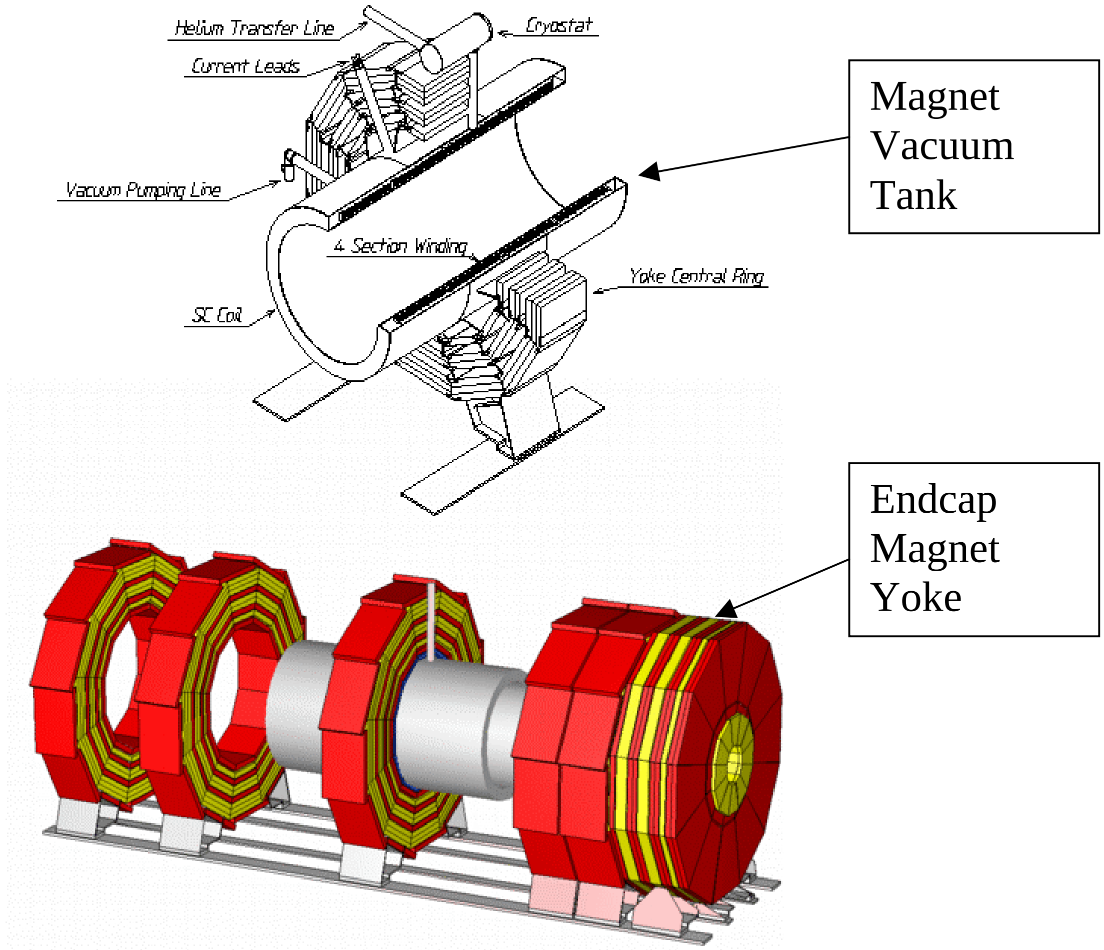


Figure 8

The US CMS contribution is made by material acquisitions rather than by cash payments. The two major efforts in US CMS are related to the US CMS interests in the hadron calorimeter and the forward muon system. This may evolve, as the cost experience with CMS Common Projects becomes clearer (i.e., we may be able to provide more or less than currently planned in the way of material acquisitions based on real cost experience.)

The US takes full responsibility for the design and procurement of the endcap steel yoke (shown as the yellow toroids in Figure 8 bottom). The US also takes partial responsibility for the barrel yoke and the coil vacuum tank (shown in Figure 8 Top). These two projects have already been bid and the contract for the endcap will be awarded within a few months. The contract for the barrel is already in place.

WBS 1.7 – Project Office:

This work breakdown structure element includes all the effort needed to exercise Project Management in CMS. The tasks include:

Baseline Development

The first phase of the US CMS Project is to construct a baseline cost estimate, have it reviewed, and accepted by the DOE and NSF as an acceptable estimate of the set of deliverables which can be supplied with high confidence for the total funding available to the project.

Tracking

A major function of the US CMS project office is tracking the progress of the project. That function includes the overall level 1 schedule, the level 2 linked schedules, and the derived annual Statement of Work. The actual costs are to be reported at the lowest work breakdown structure level by means of invoices to the Fermilab general ledger.

Reporting

The US CMS project office will report to the Fermilab Project Management Group, the DOE/NSF Project Manager, and the Joint Oversight Group in a manner specified by those entities.

Northeastern University Administration

The NSF funds will be sent from NSF to Northeastern University. They will be divided then as per instruction of the technical director/construction project manager and sent to the NSF supported groups of US CMS. In order to perform these functions, Northeastern University requires the services of an Administrative Assistant.

Support for Education/Outreach

The education liaison function includes the development of educational proposals of US CMS. In support of these and other educational activities, the US CMS project office supplies funds for programmatic travel and for M&S supplies.

Appendix 3: US CMS Schedule Baseline

JOG*	Date		APM / DD**	Date
1 DOE/NSF CERN Agreement	Dec-97	CP	1 Move 2nd Year Funding for CP Package A	Oct-98
2 Approve Baseline	Jul-98	EMU	2 Muon CSC*** Factory Start	Jan-99
3 Approve Project Management Plan	Sep-98	HCAL	3 HCAL Optics Factory Start	Jan-99
4 US CMS Project Complete	Oct-05	HCAL	4 1st 18 Wedges Optics @ CERN	Jun-00
		HCAL	5 1st 18 Wedges HCAL Brass @ CERN	Nov-00
		FPIX	6 FPIX Cooling Distribution Design Complete	Jan-01
		CP	7 4th Year CP Package A Payment Complete	Jun-01
		EMU	8 1st 17 EMU CSC Chambers Complete	Jun-01
		HCAL	9 Finish Production Brass Wedges @ CERN	Dec-01
		HCAL	10 Finish Production Optical System @ CERN	Dec-01
		HCAL	11 HCAL Electronics Complete @ CERN	Jan-02
		ECAL	12 Final Prod ECAL Serializer Wafer	Feb-02
		TriDAS	13 Trigger MPC Board Assembly Complete	Jan-03
		Inst	14 Start CMS Installation in Pit	Jan-03
		CP	15 HE+YE+ connect	Jan-03
		CP	16 HB in Vacuum Tank Test	Mar-03
		CP	17 HE-YE- connect	May-03
		EMU	18 1st Half CSC Assembly at CERN Complete	Jul-03
		TriDAS	19 DAQ Event Manager Boards Complete	Aug-03
		CP	20 Magnet Full Field Test Completed @ CERN	Sep-03
		Inst	21 BO Underground Counting House	Sep-03
		ECAL	22 Complete Production of APDs	Sep-03
		Inst	23 Install Magnet in Collision Hall	Oct-03
		EMU	24 All ME234/2 Assembled & Tested	Oct-03
		EMU	25 EMU Electronics Complete	Dec-03
		ECAL	26 Forward Pixels Shipped to CERN	Sep-04
		All	27 US CMS Construction Complete	Sep-04

* JOG - Joint Oversight Group Controlled Milestones

** APM / DD - Agency Project Manager / Fermilab Deputy Director Controlled Milestones

*** See Acronym List

Appendix 4: US CMS Cost Baseline

WBS Number	Description	Cost (k$)
1	Endcap Muon	$26,551
2	Hadron Calorimeter	$30,255
3	Trigger and Data Acquisition	$12,393
4	Electromagnetic Calorimeter	$7,728
5	Forward Pixels	$5,208
6	Common Projects	$23,714
7	Project Office	$5,738
	Subtotal	**$111,587**
	Contingency	$48,743
	FY 96 & FY 97	$6,920
	Total Project Cost	**$167,250**

Appendix 5: US CMS Major Procurements

1. Endcap Muon

ID	WBS	Item	Cost K$	Start Date*	Finish Date**	Institution	Planned Funding
114	1.1.3.2.4.1	FY1998 (15 ME23/2)	109,605	01-Jul-98	22-Sep-98	Fermilab	DOE
86	1.1.1.4.8	Tooling Upgrade Development	129,808	06-Jan-99	19-Dec-01	Fermilab	DOE
179	1.1.3.3.4.1	FY1999 (23 ME23/2 chambers)	168,866	06-Jan-99	29-Jun-99	Fermilab	DOE
115	1.1.3.2.4.2	FY1999 (29 ME23/2, 19 ME ME23/1, 37 ME1/23)	426,161	01-Jul-99	22-Sep-99	Fermilab	DOE
890	1.2.4.3.1.1	Procure FPGA/EPROM set #1	112,210	01-Oct-99	18-Feb-00	Rice	DOE
633	1.2.1.3.2.4.1	Procure Latch ASIC Set #1	114,935	01-Nov-99	20-Mar-00	UCLA	DOE
769	1.2.2.3.2.2.1	Procure Latch ASIC Set #1	108,203	01-Nov-99	20-Mar-00	UCLA	DOE
180	1.1.3.3.4.2	FY2000 (50 ME23/2 chambers)	367,100	06-Jan-00	28-Jun-00	Fermilab	DOE
332	1.1.3.4.6.1.1	19 ME23/1 worth of materials	108,167	06-Jan-00	20-Dec-00	Fermilab	DOE
336	1.1.3.4.6.2.1	37 ME1/23 worth of materials	178,747	06-Jan-00	20-Dec-00	Fermilab	DOE
977	1.6.2.1.3	procure CU pads	137,000	06-Jan-00	01-Mar-00	Wisconsin	DOE
116	1.1.3.2.4.3	FY2000 (42 ME23/2, 19 ME ME23/1, 37 ME1/23)	521,152	03-Jul-00	22-Sep-00	Fermilab	DOE
654	1.2.1.3.3.2	Procure PC Board Set #1	188,270	15-Sep-00	07-Dec-00	Ohio State	DOE
782	1.2.2.3.3.2	Procure PC Board Set #1	160,736	18-Sep-00	08-Dec-00	UCLA/CMU	DOE
891	1.2.4.3.1.2	Procure FPGA/EPROM set #2	112,210	02-Oct-00	16-Feb-01	Rice	DOE
181	1.1.3.3.4.3	FY2001 (50 ME234/2 chambers)	367,100	04-Jan-01	27-Jun-01	Fermilab	DOE
333	1.1.3.4.6.1.2	19 ME23/1 worth of materials	108,167	04-Jan-01	19-Dec-01	Fermilab	DOE
337	1.1.3.4.6.2.2	37 ME1/23 worth of materials	178,747	04-Jan-01	19-Dec-01	Fermilab	DOE
970	1.6.1.2	procure parts	160,000	02-Apr-01	01-Jul-01	Wisconsin	DOE
655	1.2.1.3.3.3	Procure PC Board Set #2	188,270	25-Jun-01	14-Sep-01	Ohio State	DOE
783	1.2.2.3.3.3	Procure PC Board Set #2	160,736	26-Jun-01	17-Sep-01	UCLA/CMU	DOE
117	1.1.3.2.4.4	FY2001 (42 ME23/2, 19 ME ME23/1, 37 ME1/23)	521,152	02-Jul-01	21-Sep-01	Fermilab	DOE
955	1.4.1.2	procure fixture parts	100,000	02-Jul-01	01-Oct-01	Wisconsin	DOE
892	1.2.4.3.1.3	Procure FPGA/EPROM set #3	112,210	01-Oct-01	18-Feb-02	Rice	DOE
182	1.1.3.3.4.4	FY2002 (25 ME234/2 chambers)	183,550	04-Jan-02	27-Jun-02	Fermilab	DOE
334	1.1.3.4.6.1.3	38 ME23/1 worth of materials	216,334	04-Jan-02	19-Dec-02	Fermilab	DOE
338	1.1.3.4.6.2.3	74 ME1/23 worth of materials	357,494	04-Jan-02	19-Dec-02	Fermilab	DOE
866	1.2.3.3.3	FED/DDU (Interface in DAQ crate)	166,382	01-Apr-02	21-Jan-04	Ohio State	DOE
656	1.2.1.3.3.4	Procure PC Board Set #3	188,270	24-Jun-02	13-Sep-02	Ohio State	DOE
784	1.2.2.3.3.4	Procure PC Board Set #3	160,736	26-Jun-02	17-Sep-02	UCLA/CMU	DOE
118	1.1.3.2.4.5	FY2002 (20 ME23/2, 19 ME ME23/1, 37 ME1/23)	360,398	01-Jul-02	20-Sep-02	Fermilab	DOE
487	1.1.7.3.1	HV Power Supplies	292,744	06-Jan-03	27-Jun-03	UF	DOE
488	1.1.7.3.2	HV Power Supplies	292,744	07-Jan-04	29-Jun-04	UF	DOE
TOTAL			**33**				

* Start Date: Contract award date.

** Finish Date: Item completed at factory or delivered.

2. Hadron Calorimeter

ID	WBS	Item	Cost K$	Start Date*	Finish Date**	Institution	Planned Funding
845	2.1.10.1.5.1	PPP1 M&S Funding (FY97)	199,480	30-Sep-97	30-Sep-97	FNAL	DOE
883	2.1.10.1.9.2	Motion Table M&S	240,000	30-Jan-98	26-Feb-98	Roch	DOE
858	2.1.10.1.6.3	Fabricate, Machine, and Assemble PPP2	196,680	16-Nov-98	01-Mar-99	FNAL	DOE
176	2.1.2.2.2.1	3.7 mm Scintillator (m**2)	205,823	06-Jan-99	02-Feb-99	Roch	DOE
10	2.1.1.2.1	Fabrication and Machining for HB-1 (P1-18)	1,464,586	01-Oct-99	31-Mar-00	FNAL	DOE
369	2.1.4.3	HPD19 (HB-1)	180,000	01-Oct-99	07-Apr-00	Notre Dame	NSF
12	2.1.1.2.3	Rail Support Plunger System (4 wedges total)	200,000	13-Oct-99	12-Apr-00	FNAL	DOE
1378	2.3.2.2.1	3.7 mm Scintillator (m**2)	254,800	14-Oct-99	10-Nov-99	Roch	DOE
1476	2.3.4.2	HPD19 HE	270,000	10-Apr-00	26-Jan-01	Notre Dame	NSF
227	2.1.2.3.2.1	3.7 mm Scintillator (m**2)	205,823	01-Jun-00	28-Jun-00	Roch	DOE
19	2.1.1.3.1	Fabrication and Machining for HB+1 (P19-36)	1,464,586	02-Oct-00	02-Mar-01	FNAL	DOE
15	2.1.1.2.6	Disassemble and Ship HB-1 Wedges and Barrel Cradle	2,196,879	04-Oct-00	14-Nov-00	FNAL	DOE
427	2.1.5.2.1.6	Channel Control ASIC Engineering Run	125,000	05-Oct-00	29-Nov-00	FNAL	DOE
459	2.1.5.3.2.1	Optical Transmitter Acquisition	164,160	18-Jan-01	14-Feb-01	FNAL	DOE
380	2.1.4.10	HPD19 (HB+1)	180,000	29-Jan-01	15-Jun-01	Notre Dame	NSF
2045	2.5.2.4.1.1.1.2.1	QP Fibers - US	166,600	01-May-01	20-Aug-01	Fairfield	DOE
2072	2.5.2.4.1.2.1.2.1	QP Fibers - US	166,600	01-May-01	20-Aug-01	Fairfield	DOE
1148	2.2.4.8	HPD19: HOB+-	240,000	03-Sep-01	01-Apr-02	Notre Dame	NSF
21	2.1.1.3.3	Disassemble Wedges and Ship HB+1 and Barrel Cradle	2,196,879	13-Sep-01	24-Oct-01	FNAL	DOE
2101	2.5.2.4.2.1.1.2.1	QP Fibers - US	166,600	01-Apr-02	19-Jul-02	Fairfield	DOE
2128	2.5.2.4.2.2.1.2.1	QP Fibers - US	166,600	01-Apr-02	19-Jul-02	Fairfield	DOE
2183	2.5.4.1	Purchase PMTs	545,325	01-May-02	19-Feb-03	Nebr	NSF
619	2.1.7.1.2.1	VME Readout Module Acquisition	341,504	01-Oct-02	08-Apr-03	FNAL	DOE
638	2.1.7.2.4.1	VME Transition Module Acquisition	138,736	01-Oct-02	08-Apr-03	FNAL	DOE
1217	2.2.7.1.1	VME Readout Module Acquisition	133,632	01-Oct-02	08-Apr-03	FNAL	DOE
1554	2.3.7.1.1	VME Readout Module Acquisition	237,568	01-Oct-02	08-Apr-03	FNAL	DOE
2343	2.5.7.1.1	VME Readout Module Acquisition	118,784	01-Oct-02	28-Oct-02	FNAL	DOE
2389	2.5.8.1.6.1	High Voltage Module Acquisition	118,980	11-Feb-04	09-Mar-04	Fairfield	DOE
TOTAL			**28**				

* Start Date: Contract award date.

** Finish Date: Item completed at factory or delivered.

3. Trigger and Data Acquisition

ID	WBS	Item	Cost K$	Start Date*	Finish Date**	Institution	Planned Funding
267	3.1.2.8.2.2	RC Parts	1,187,200	02-Jul-01	28-Jan-02	WISC	DOE
268	3.1.2.8.2.3	RC Board	128,000	27-Aug-01	28-Jan-02	WISC	DOE
276	3.1.2.9.2.2	EIC Parts	478,400	03-Sep-01	01-Apr-02	WISC	DOE
270	3.1.2.8.2.5	16 RC Spares/Preprod	141,920	17-Sep-01	20-May-02	WISC	DOE
269	3.1.2.8.2.4	RC Assembly	104,000	29-Jan-02	20-May-02	WISC	DOE
188	3.2.5.4.3	FUS Order 1	172,800	03-Jul-02	08-Jan-03	UCLA	NSF
202	3.2.5.5.3	Crates order 1	102,400	03-Jul-02	24-Sep-02	MIT	DOE
206	3.2.5.5.7	Crates order 2	204,800	06-Nov-02	12-Feb-03	MIT	DOE
146	3.2.5.1.3	FUI Order 1	243,200	13-Nov-02	21-May-03	MIT	DOE
160	3.2.5.2.3	FUO Order 1	166,400	13-Nov-02	21-May-03	UCSD	DOE
174	3.2.5.3.3	FUM Order 1	192,000	13-Nov-02	21-May-03	UCSD	DOE
192	3.2.5.4.7	FUS Order 2	345,600	04-Apr-03	25-Sep-03	UCLA	NSF
164	3.2.5.2.7	FUO Order 2	332,800	27-May-03	18-Nov-03	UCSD	DOE
178	3.2.5.3.7	FUM Order 2	384,000	27-May-03	18-Nov-03	UCSD	DOE
150	3.2.5.1.7	FUI Order 2	486,400	21-Aug-03	27-Feb-04	MIT	DOE
TOTAL			**15**				

*   Start Date: Contract award date.

** Finish Date: Item completed at factory or delivered.

4. Electromagnetic Calorimeter

ID	WBS	Item	Cost K$	Start Date*	Finish Date**	Institution	Planned Funding
61	4.1.3.1	Manufacture APD's	100,000	20-Oct-97	23-Mar-98	Minnesota	DOE
87	4.1.4.1	Process Engineering	120,000	13-Jul-98	25-Jan-99	Minnesota	DOE
250	4.2.5.2	Package Production Barrel	220,320	28-Jul-98	14-Dec-98	Princeton	DOE
175	4.2.1.20	FPU v3 DMILL	125,000	01-Oct-98	18-Jan-99	Princeton	DOE
253	4.2.5.5	Readout Card Production Barrel	372,000	11-Nov-98	01-Sep-99	Princeton	DOE
274	4.3.3.1.2	Laser Purchasing	170,000	12-Nov-98	15-Apr-99	Caltech	DOE
91	4.1.4.3	Fabricate 2000 APD's	125,000	09-Mar-99	15-Nov-99	Northeastern	NSF
119	4.1.6.2.1	Procure 9,000 APD's	379,827	01-Oct-99	29-Sep-00	Northeastern	NSF
182	4.2.1.26.1	FY00 purchase	243,600	01-Oct-99	04-Feb-00	Princeton	DOE
223	4.2.4.2.12.1	FY00 Production	434,070	19-Jan-00	06-Jun-00	Princeton	DOE
120	4.1.6.2.2	Procure 9,000 APD's	379,827	02-Oct-00	28-Sep-01	Northeastern	NSF
185	4.2.1.26.4	FY01 purchase	243,600	02-Oct-00	27-Oct-00	Princeton	DOE
226	4.2.4.2.12.4	FY01 Production	434,070	02-Oct-00	02-Mar-01	Princeton	DOE
188	4.2.1.26.7	FY02 purchase	243,960	01-Oct-01	26-Oct-01	Princeton	DOE
229	4.2.4.2.12.7	FY02 Production	434,070	01-Oct-01	04-Mar-02	Princeton	DOE
121	4.1.6.2.3	Procure 9,000 APD's	379,827	11-Oct-01	30-Sep-02	Northeastern	NSF
122	4.1.6.2.4	Procure 9,000 APD's	379,827	01-Oct-02	18-Sep-03	Northeastern	NSF
TOTAL			**17**				

*   Start Date: Contract award date.

** Finish Date: Item completed at factory or delivered.

5. Forward Pixels

ID	WBS	Item	Cost K$	Start Date*	Finish Date**	Institution	Planned Funding
93	5.1.3.1.3.1	procurement	184800	27-Sep-01	23-May-02	JHU	NSF
230	5.2.3.3	Production	300000	14-May-02	15-Apr-03	JHU	NSF
24	5.1.1.2.1	Production	600000	15-May-02	17-Oct-02	JHU	NSF
109	5.1.4.2.1	See e-mail form Jeoff Hall of 980417, included in the BOE folder.	150000	29-Apr-04	01-Aug-04	JHU	NSF
449	5.3.2.2.1.1	refrigerator procured	150000	17-Aug-04	23-Aug-04	Miss.	DOE
TOTAL			**5**				

* Start Date: Contract award date.

** Finish Date: Item completed at factory or delivered.

6. Common Projects

ID	WBS	Item	Cost K$	Start Date*	Finish Date**	Inst.	Planned Funding
10	6.1.5.2	End Cap Iron Return Yoke 98	2,740,000	01-Oct-97	30-Sep-98	Fermilab	DOE
24	6.2.5.2	End Cap Iron Return Yoke 98	1,580,000	01-Oct-97	30-Sep-98	Wisconsin	DOE
11	6.1.5.3	End Cap Iron Return Yoke 99	2,520,800	01-Oct-98	01-Nov-99	Fermilab	DOE
25	6.2.5.3	End Cap Iron Return Yoke 99	3,646,000	01-Oct-98	30-Sep-99	Wisconsin	DOE
26	6.2.5.4	End Cap Iron Return Yoke 00	3,192,000	01-Oct-99	29-Sep-00	Wisconsin	DOE
12	6.1.5.4	End Cap Iron Return Yoke 00	2,723,200	01-Nov-99	30-Nov-00	Fermilab	DOE
27	6.2.5.5	End Cap Iron Return Yoke 01	2,799,000	02-Oct-00	28-Sep-01	Wisconsin	DOE
14	6.1.5.6	End Cap Iron Return Yoke 02	119,600	22-Jun-01	24-Jul-02	Fermilab	DOE
28	6.2.5.6	End Cap Iron Return Yoke 02	1,692,000	01-Oct-01	30-Sep-02	Wisconsin	DOE
29	6.2.5.7	End Cap Iron Return Yoke 03	338,000	01-Oct-02	30-Sep-03	Wisconsin	DOE
30	6.2.5.8	End Cap Iron Return Yoke 04	338,000	01-Oct-03	30-Sep-04	Wisconsin	DOE
TOTAL			**11**				

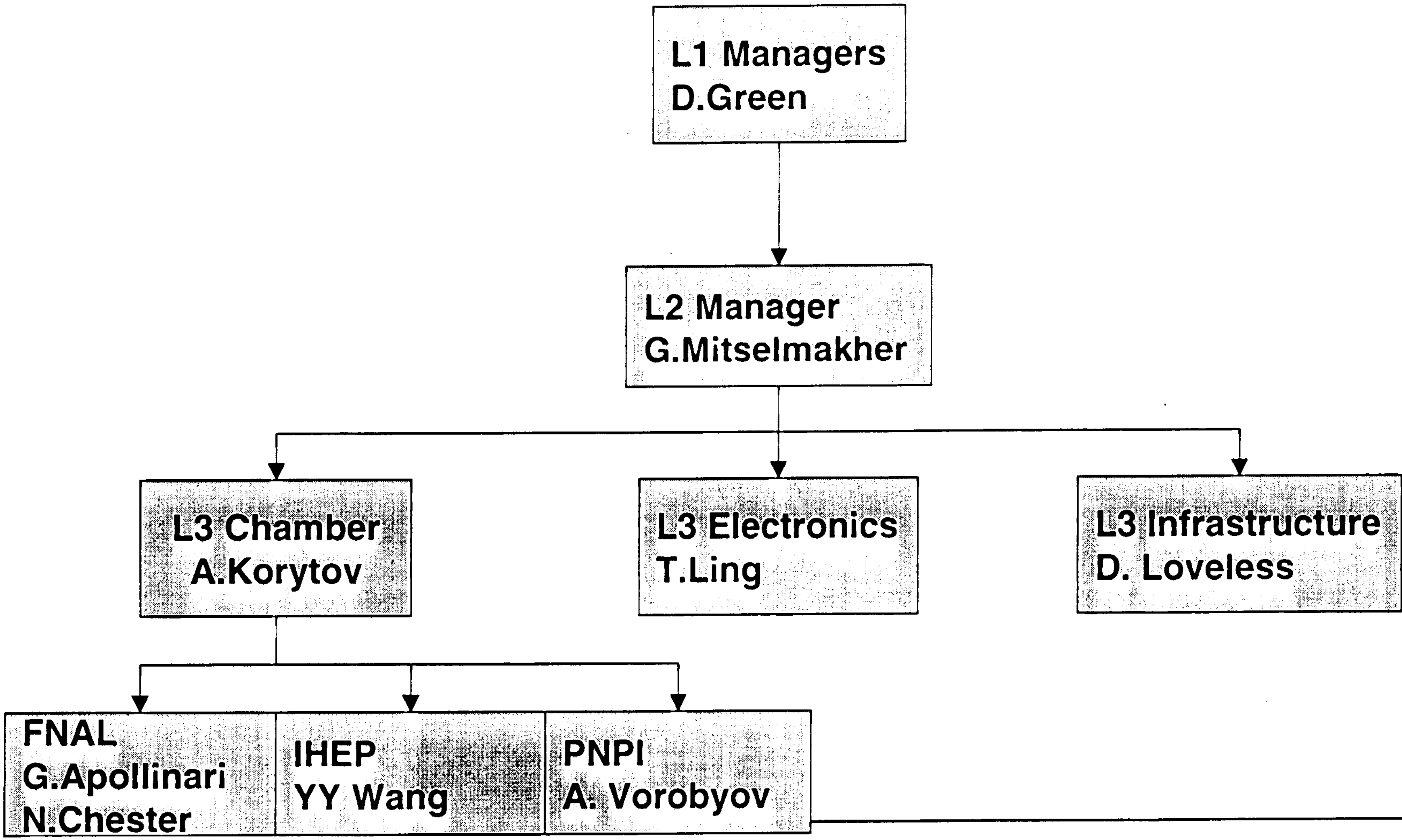
* Start Date: Contract award date.

** Finish Date: Item completed at factory or delivered.

Appendix 6: Proposed US CMS Project Management Change Control Thresholds

	Level 0	Level 1	Level 2	Level 3a	Level 3b
	DOE Director of Energy Research /NSF Director of Mathematical and Physical Sciences	DOE/NSF Joint Oversight Group	DOE/NSF (Agency) Project Manager	Fermilab Deputy Director	US CMS Technical Director & Construction Project Manager
Technical	Changes that require modification to the US/CERN Agreement and Experiments Protocol	Approve the technical baseline as described in Appendix 2: US CMS Technical Baseline Document.	Significant changes to the technical baseline as described in Appendix 2: US CMS Technical Baseline Document.	Any change in scope that has a significant impact on the physics performance of a sub-detector, including trade-offs among subdetectors Significant changes in scope or detailed design of sub-detectors.	Any change in scope or physics performance of a subdetector, including trade-offs among subdetectors. Changes in scope or detailed design of subdetectors as documented in the Design Handbook.
Schedule	Changes that require modification to the US/CERN Agreement and Experiments Protocol.	Greater than six month change in a Level 1 milestone. [Appendix 3: US CMS Baseline Schedule.]	Greater than three month change in a Level 2 milestone. [Appendix 3: US CMS Baseline Schedule.]	Greater than three month change in a Level 2 milestone. [Appendix 3: US CMS Baseline Schedule.]	Greater than a one month change in a Level 2 milestone. [Appendix 3: US CMS Baseline Schedule.] Greater than one month change to milestones defined by the CPM and TD.
Cost	Changes that require modification to the US/CERN Agreement and Experiments Protocol.	Any change to the US CMS Total Project Cost (TPC).	Cumulative changes greater than $2.5 million to the US CMS cost baseline at WBS Level 2. [Appendix 4: US CMS Cost Baseline.]	Cumulative changes greater than $1.0 million to the US CMS cost baseline at WBS Level 2. [Appendix 4: US CMS Cost Baseline.]	Cumulative changes in the cost baseline of $100 thousand at WBS Level 2. [US CMS Cost Estimate dated May 1998.]

- **US CMS and CMS-EMU Organization Structure**



Statement of Work

by

the US CMS Group at Fermilab

for Activities Related to the US CMS Endcap Muon Subsystem

During Fiscal Year 2002

March 20, 2002

1. Introduction

This Statement of Work (SOW) is made to provide the yearly details of the work agreed to between the US CMS Project and the US CMS group at Fermilab. It covers the specific period of performance from October 1, 2001 through September 30, 2002.

2. Personnel

2.1. List of Scientific Personnel

Participating scientists with anticipated fraction of their research time committed to CMS during this period of performance are listed below. No support for these individuals comes from project funds.

Name	CMS Fraction	Other Research Commitments/Comments
G. Apollinari	80%	CDF (20%)
D. Eartly	100%	
R. H. Lee	66%	
K. Maeshima	50%	
O. Prokofiev	100%	

2.2. List of Technical Personnel

Participating technical personnel with the anticipated fraction of their time (time fractions are estimates and are not cost shares) committed to CMS during this period of performance and their source(s) of support are indicated below. The possible sources are DUS = DOE, US CMS Project; NUS = NSF, US CMS Project; DBG = DOE base grant; NBG = NSF base grant, UID = university infrastructure, DOE-supported group; and UIN = university infrastructure, NSF-supported group as shown in the WBS. The WBS numbers at L7 to which the salary costs should be charged should be filled in with the appropriate fraction of the salary charge if this cost is covered by a grant supplement. The cost on the CMS Project will be assigned algorithmically in the case of a grant supplement, That cost will be assigned to the WBS numbers given below with a weight equal to the salary fraction. The sum of the salary fractions should equal one.

Engineers

Name	CMS Fraction (%)	Cost on CMS Project this FY (k$)	Source of Support	WBS #'s	Salary fraction
N. Chester	100%	AAA$	DOE	1.8.2.2	100%
J. Brandt	25%	BBB$	DOE	1.8.1.1.7.2	100%
V. Razmyslovich	50%	CCC$	DOE	1.8.1.1.7.7	100%
V. Sknar (alignment)	25%	-	CMS Visitor	1.7.7.5, 1,7,6,8	-

Designers

Name	CMS Fraction (%)	Cost on CMS Project this FY (k$)	Source of Support	WBS #'s	Salary fraction
P. Belko	25%	DDD$	DOE	1.8.1.1.7.2	100%

Technical Specialists

Name	CMS Fracti on (%)	Cost on CMS Project this FY (k$)	Source of Support	WBS #'s	Salary fraction
P. Deering (Lab 8 Supervisor)	50%	-	Base Program	-	50%
Lab 8 Technicians (3.2 techs)	100%	EEE$	DOE	1.8.4.2.9.5	100%
G.Smith (MP9 Supervisor)	100%	FFF$	DOE	1.8.4.3.1	100%
J. Wittenkeller (MP9 Lead)	100%	GGG$	DOE	1.8.4.3.8.8	
MP9 Technicians (6 techs)	100%	HHH$	DOE	1.8.4.3.8.9	100%
Documentation/Travelers (1.2 techs)	100%	III$	DOE	1.8.1.1.7.1.4	100%
Inspection (0.2 techs)	100%	JJJ$	DOE	1.8.3.1.1.4	20%
Chamber Parts Shipment (0.6 techs)	100%	KKK$	DOE	1.8.3.1.2.3	60%
Integration Parts Shipment (0.3 techs)	100%	LLL$	DOE	1.6.2.1.8	30%

Programmers

Name	CMS Fraction (%)	Cost on CMS Project this FY (k$)	Source of Support	WBS #'s	Salary fraction
E. Orischin (alignment)	25	-	CMS Visitor	1.7.5.5.2	-

Others

Name	CMS Fraction (%)	Cost on CMS Project (k$)	Source of Support	WBS #'s	Salary fraction

3. Responsibilities for this Period of Performance

3.1 WBS Items at L7, Estimated Cost and Deliverable

During this period of performance the US CMS group at Fermilab agrees to supply the following deliverables at a cost not to exceed the estimated base cost given in the US CMS WBS. The following itemized list describes the items (or partial completion of items) provided in this period (Statements of Work).

WBS (L7)	Task - Deliverable	WBS Base Cost (FY00$)	FY02 Cost (FY02$)	FNAL MPO	DOE Suppl.	NSF
1.1.3.1	Physicist in charge for production at Fermilab	0	0	0		0
1.6.2.1.3	procure Cu pads	270,100	0	0		0
1.6.2.1.8.2	ship On-chamber parts to PNPI FY02	15,199	15,984	15,984		0
1.6.2.1.8.4	ship On-chamber parts to IHEP FY02	15,199	15,984	15,984		0
1.6.2.1.8.5	Ship On-chamber Electronics to Dubna (ME11)	14,000	14,723	14,723		0
1.6.2.1.8.6	Labor for shipment parts to Dubna (ME11)	10,000	10,516	10,516		0
1.6.2.1.8.7	Labor for shipment on-chamber parts to PNPI & IHEP	34,000	35,756	35,756		0
1.7.8.2.3.2	test & calib.	1,500	1,577	0		1,577
1.7.8.2.4.4	test & calib.	3,750	3,944	0		3,944
1.7.8.2.5.2	test & calib.	3,000	3,155	0		3,155
1.7.8.2.6.2	test & calib.	1,950	2,051	0		2,051
1.7.8.2.7.3	test & calib.	1,950	2,051	0		2,051
1.7.8.3.1.5	Analog test facility	5,000	1,528	0		1,528
1.7.8.4.8	quality assurance	0	0	0		0
1.8.1.1.7.1.4	FY02 Documentation/Travelers	102,500	107,794	107,794		0
1.8.1.1.7.2.6	Finishing Integration in FY02	56,250	59,155	59,155		0
1.8.1.1.7.7	Finishing Integration of ME3/1, ME4/1, ME1/3	21,000	22,085	22,085		0
1.8.2.2.4	Production Engineer in FY02	180,000	189,297	189,297		0
1.8.2.4.2	Technical coordination related to primary assembly-FY00	137,600	34,626	34,626		0
1.8.3.1.1.4	FY02 Inspection	23,998	25,238	25,238		0
1.8.3.1.2.3	FY02 Kit Preparation	37,000	38,911	38,911		0
1.8.3.3.13.4	Epoxy in FY2002	19,300	20,297	20,297		0
1.8.3.3.14.4	Scotch Tape in FY2002	1,675	1,762	1,762		0
1.8.3.3.15.4	RTV in FY2002	10,700	11,253	11,253		0
1.8.4.1	Physicist in charge for production at Fermilab	0		0		0
1.8.4.2.1	Panel Production Supervision	0		0		0
1.8.4.2.5.4	Gerber and Axxiom MaintenanceFY02	10,040	10,559	10,559		0
1.8.4.2.6.4	Milling BitsFY02	7,560	7,950	7,950		0
1.8.4.2.9.5	Lab 8 manpower FY02	214,712	225,802	225,802		0
1.8.4.3.1.2	Chamber Assembly Supervision	476,320	139,743	139,743		0
1.8.4.3.2	Physicist at MP9 and Lab 7	0		0		0
1.8.4.3.8.8	Lead Tech	196,500	80,725	80,725		0
1.8.4.3.8.9	Six Assembly Techs	943,200	387,478	387,478		0
1.8.4.3.8.10.1	Visitor 1	75,000	32,261	32,261		0
1.8.4.3.8.10.2	Visitor 2	75,000	32,261	32,261		0
1.8.4.3.8.12	Overtime at MP9	42,066	27,049	27,049		0
1.8.4.3.12.1.4	Gas Expenses-FY02	4,160	4,375	4,375		0
1.8.4.3.12.2.3	Station Maintenance-FY02	10,080	10,601	10,601		0

1.8.4.3.12.3.4	48 ME23/2 chambers - crates	9,000	9,465	9,465		0
1.8.4.3.12.4.7	6th-9th 6-CSC racks are shipped to UF	8,000	8,413	8,413		0
1.8.4.3.12.4.8	6th-9th 6-CSC racks are shipped to UCLA	12,000	12,620	12,620		0
1.8.4.4.1	Physicist overseeing shipments to Foreign Sites	0		0		0
1.8.4.4.5.2	Shipping Panels+M&S to PNPI - 2002 (26 ME23/1)	11,000	11,568	11,568		0
1.8.4.4.5.4	PNPI Critical Tooling Maintenance	30,000	0	0		0
1.8.4.4.11.2	Shipping Panels+M&S to IHEP - 2002 (48 ME1/23)	12,900	13,566	13,566		0
1.8.4.4.11.4	IHEP Critical Tooling Maintenance	30,000	0	0		0
1.8.7.2.7	Equipment for chamber pre-tests at CERN	31,998	33,651	33,651		0
1.8.7.2.9	Storage/Pre-tests at CERN expenses-FY02	0	0	0		0
Total Cost			1,665,772	1,651,466	0	14,306

3.2. Coordination and Reporting

The US CMS Level 2 Manager for the Endcap Muon subsystem is Guenakh Mitselmakher. The institution contact person for Endcap Muon activities at Fermilab is Giorgio Apollinari for the CSC factory and David Eartly for the CSC alignment. The task managers for Endcap Muon activities carried out by the US CMS group at Fermilab are as follows:

Task	Task Manager
CSC Construction	G. Apollinari
Alignment System	D. Eartly
Integration Parts Shipment	O. Prokofiev

3.3. Procurement Authorization

Item purchases exceeding the delegated limit (currently $10k) must be authorized in advance of obligation by the US CMS Level 2 manager. Major procurements (currently $100k) must in addition have the written authorization of the US CMS Construction Project Manager. Items purchased as CMS Common Project items must be explicitly authorized by the US CMS Construction Project Manager and approved by the CMS Resource Manager, regardless of the cost.

3.4. Reporting to US CMS Project Management

The US CMS group at Fermilab will report all CMS related expenditures and labor charges together with associated technical progress in each item of work by Work Breakdown Structure (WBS) category (Level 7).

Technical progress will be reported by WBS element L4 to the Level 2 Manager and the TD/CPM on a quarterly basis and will cover all items covered in this Statement of Work regardless of the specific nature of the funding support.

The US CMS group at Fermilab agrees to furnish complete documentation of the quality control and performance checks which are carried out for US CMS in the performance of this work.

3.5. Collaboration with Other Groups and Institutions

Design, construction and installation related to the Endcap Muon subsystem will be carried out in close communication and collaboration with other groups working on this and related subsystems.

WBS / Task (L4)	Collab. Group	Responsibility with US CMS group at Fermilab

1.7.7	UWisc	Alignment system test parts
1.7.6, 1.7.7, 1.7.8	NEU	Alignment system design and tests
1.7.6, 1.7.7, 1.7.8	PNPI	Alignment system design and tests

4. Contribution of Effort, Services and Equipment

Subject to adequate funding by DOE or NSF, the US CMS group at Fermilab will provide support for the scientific and technical personnel as indicated in section 2 during this period of performance. This contribution refers only to support provided outside the US CMS Project.

5. Fermilab (as host institution) Effort, Services and Facilities

Tracking of Fermilab CMS support, whether provided by Fermilab or paid by the US CMS Project, will be done using appropriate effort reporting codes. The costs incurred will be reported to the Fermilab Director.

Contributing Fermilab personnel with the anticipated fraction of their time committed to CMS during this period of performance and their source(s) of support are:

5.1. Administrative Staff

Name	CMS Fraction	Source of Support

5.2. Engineers

Name	CMS Fraction	Source of Support

5.3. Designers

Name	CMS Fraction	Source of Support

5.4. Technical Specialists

Name	CMS Fraction	Source of Support

5.5. Programmers

Name	CMS Fraction	Source of Support

5.6. Others

Name	CMS Fraction	Source of Support

6. Costs and Funding

A total amount of $1,665,772 is detailed above for the full fiscal year. The MPO portion will be paid upon receipt and approval of invoices for the work by the Project Office at Fermilab. Management control requires the review and concurrence of the Level 2 Manager and the Project Office, as needed, for major expenditures, as defined above. The release of funds above the given thresholds will be contingent upon this concurrence.

7. Schedules and Milestones

The US CMS group at Fermilab will make every effort to carry out their institutional responsibilities consistent with the overall CMS schedule. In this Statement of Work are listed the program milestones for this period of performance.

The program milestones for this period of performance relevant to the US CMS group at Fermilab are listed here:

WBS	Program Milestones	Baseline Milestone Date	Current Milestone Date
1.8.1.1.23	Sign off ME1/3 Chamber Drawings		12/07/01
1.8.1.1.30	Sign-off Integration Drawings for ME2/1 Chambers		12/07/01
1.8.1.1.31	Sign-off Integration Drawings for ME3/1 Chambers		02/07/02
1.8.1.1.32	Sign-off Integration Drawings for ME1/3 Chambers		12/07/01
1.8.1.1.33	Sign-off Integration Drawings for ME4/1 Chambers		04/08/02
1.8.4.2.11	"+42=106 ME23/2, +20=40 ME23/1, +36=72 ME1/23 panels made"		10/01/01
1.8.4.2.14	38 ME4/1 panels delivered		06/03/02
1.8.4.3.9	+54=66 ME23/2 chambers assembled		01/31/02
1.8.4.3.10	+54=120 ME23/2 chambers assembled		09/30/02
1.10.1.1.2	52 ME23/2s assembled at Fermilab		10/30/01
1.10.1.1.3	57 ME23/2s assembled at Fermilab		11/30/01
1.10.1.1.4	61 ME23/2s assembled at Fermilab		12/31/01
1.10.1.1.5	66 ME23/2s assembled at Fermilab		01/31/02
1.10.1.1.6	72 ME23/2s assembled at Fermilab		02/28/02
1.10.1.1.7	78 ME23/2s assembled at Fermilab		03/31/02
1.10.1.1.8	84 ME23/2s assembled at Fermilab		04/30/02
1.10.1.1.9	90 ME23/2s assembled at Fermilab		05/31/02
1.10.1.1.10	96 ME23/2s assembled at Fermilab		06/30/02
1.10.1.1.11	102 ME23/2s assembled at Fermilab		07/31/02

1.10.1.1.12	108 ME23/2s assembled at Fermilab		08/31/02
1.10.1.1.13	114 ME23/2s assembled at Fermilab		09/30/02
1.10.1.2.2	21 Chambers shipped to UCLA FAST Site		12/17/01
1.10.1.2.3	26 Chambers shipped to UCLA FAST Site		12/17/01
1.10.1.2.4	31 Chambers shipped to UCLA FAST Site		03/15/02
1.10.1.2.5	36 Chambers shipped to UCLA FAST Site		03/15/02
1.10.1.2.6	41 Chambers shipped to UCLA FAST Site		06/17/02
1.10.1.2.7	46 Chambers shipped to UCLA FAST Site		06/17/02
1.10.1.2.8	51 Chambers shipped to UCLA FAST Site		09/16/02
1.10.1.2.9	56 Chambers shipped to UCLA FAST Site		09/16/02
1.10.1.3.1	21 Chambers shipped to UF FAST Site		12/17/01
1.10.1.3.2	26 Chambers shipped to UF FAST Site		12/17/01
1.10.1.3.3	31 Chambers shipped to UF FAST Site		03/15/02
1.10.1.3.4	36 Chambers shipped to UF FAST Site		03/15/02
1.10.1.3.5	41 Chambers shipped to UF FAST Site		06/17/02
1.10.1.3.6	46 Chambers shipped to UF FAST Site		06/17/02
1.10.1.3.7	51 Chambers shipped to UF FAST Site		09/16/02
1.10.1.3.8	56 Chambers shipped to UF FAST Site		09/16/02
1.10.2.2	38 ME3/1 CSC kits shipped to PNPI		01/31/02
1.10.2.3	38 ME4/1 CSC kits shipped to PNPI		04/30/02
1.10.3.1	74 ME1/2 CSC kits are shipped to IHEP		10/30/01
1.10.4.1.1	5 ME23/2 cooling plates are at UCLA		10/01/01
1.10.4.1.2	5 ME23/2 cooling plates are at UF		10/01/01
1.10.4.1.3	+5=10 ME23/2 cooling plates are at UCLA		12/15/01
1.10.4.1.4	+5=10 ME23/2 cooling plates are at UF		12/15/01
1.10.4.1.5	12 ME2/1 cooling plates at Fermilab ready to be shipped to PNPI		12/15/01
1.10.4.1.6	12 ME1/2 cooling plates at Fermilab ready to be shipped to IHEP		12/15/01
1.10.4.1.7	+5=15 ME23/2 cooling plates are at UCLA		02/15/02
1.10.4.1.8	+5=15 ME23/2 cooling plates are at UF		02/15/02
1.10.4.1.9	+12=24 ME2/1 cooling plates at Fermilab ready to be shipped to PNPI		02/28/02
1.10.4.1.10	+12=24 ME1/2 cooling plates at Fermilab ready to be shipped to IHEP		02/28/02
1.10.4.1.11	+10=25 ME23/2 cooling plates are at UCLA		03/31/02
1.10.4.1.12	+10=25 ME23/2 cooling plates are at UF		03/31/02
1.10.4.1.13	+14=38 ME2/1 cooling plates at Fermilab ready to be shipped to PNPI		05/15/02
1.10.4.1.14	+12=36 ME1/2 cooling plates at Fermilab ready to be shipped to IHEP		05/15/02
1.10.4.1.15	+10=35 ME23/2 cooling plates are at UCLA		06/15/02
1.10.4.1.16	+10=35 ME23/2 cooling plates are at UF		06/15/02
1.10.4.1.17	12 ME3/1 cooling plates at Fermilab ready to be shipped to PNPI		07/15/02
1.10.4.1.18	+12=48 ME1/2 cooling plates at Fermilab ready to be shipped to IHEP		07/15/02
1.10.4.1.19	+10=45 ME23/2 cooling plates are at UCLA		08/31/02
1.10.4.1.20	+10=45 ME23/2 cooling plates are at UF		08/31/02
1.10.4.1.21	+12=24 ME3/1 cooling plates at Fermilab ready to be shipped to PNPI		09/30/02
1.10.4.1.22	+12=60 ME1/2 cooling plates at Fermilab ready to be shipped to IHEP		09/30/02

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10:30 FAX 630 840 2194 SDC FERMILAB 002

US CMS FY02 SOW vers 2.0

8. Makers and Concurrence

The following persons concur in the terms of this Statement of Work. These terms will be updated as appropriate in later Statements.

Makers of this Memorandum:

3/4/02 (date)
Dan Green
US CMS Technical Director

03.04.02 (date)
David P. Eartly
US CMS Group Principal Investigator
Fermilab

03/05/02 (date)
Guenakh Mitselmakher
US CMS Level 2 Manager
Endcap Muon Subsystem

Concurrence:

4/10/02 (date)
Ken Stanfield
Deputy Director
Fermilab

Copy sent to:

4/15/02 (date)
Alain Herve
CMS Technical Coordinator

Fermi National Accelerator Laboratory

Technical Division
Headquarters

Quality Management Program

TD-2010

Version 2

Approved, TD Quality Assurance Officer

4/3/2001
Date

Approved, Technical Division Head

4/3/2001
Date

Revision History

Version	Date	Section No.	Specifics
1	3/95	All	First version
2	02-Feb-2001	All	Updated to reflect organizational and policy/procedure changes

Controlled Distribution

Technical Division Library

Introduction

Background

The Technical Division was originally organized as the Technical Support Section in the early 1980s. It was at this time that Technical Services (consisting of the Conventional Magnet Facility and the Machine Shops) and the Energy Saver Section (consisting of the Superconducting Magnet Facility and the Magnet Test Facility) were combined to create the Technical Support Section. In the mid 1990s a reorganization of the laboratory occurred and the Technical Support Section became the "Technical Division". Although research was a part of the work as a section, the change to become a division made research a major portion of the mission of the organization.

The Technical Division maintains a diverse work force that has a very wide range of core competencies. In support of the R&D the division has experts in the fields of engineering, fabrication, tooling, machining/welding, procurement, calibration, testing, operations, maintenance, QA/QC and systems integration. The division also provides services in project management, project planning, resource management and scheduling. The Technical Division is heavily involved in the work of repairing and refurbishing existing devices, as well as design, fabrication and project management of a wide variety of HEP projects, including the next generation of particle accelerators, detectors, and astrophysics experiments.

Quality Management Program

Due to the level of complexity of the work done in the Technical Division it was decided to implement a formal, documented program, which describes the practices used by the division to assure the quality of our work. Formal programs have proven to be effective in industry, if designed and implemented appropriately. *The Technical Division quality management program is applied to all the work done in the division.*

This document defines division policy and overall procedures for the organization. Although it covers the entire program, it is not meant to describe every detail of the quality program. Details regarding specific practices and procedures are maintained within each department.

The purpose of the program is to aid the division in assuring the quality of our work while not inhibiting the creativity of the people doing the work. By creating and maintaining our quality system, we are able to see and understand our organization as a *system*, not as separate groups working independently. This program is also a tool that is used to communicate and train people (both internal and external to the division) on how business is done in the division.

One of the goals of this type of program is to standardize routine processes, e.g. drawing approvals, while still being flexible and adaptable to improvements. Our desire is to have all division employees constantly challenge and push our activities to higher levels of performance, which enables us to continually innovate, improve, and learn. We strive to continually learn and improve in all that we do, which includes this program.

1.0 Program

This section describes the Technical Division quality system, and the functions and responsibilities of the departments and personnel.

The Technical Division's quality management program is based on the knowledge and expertise of the people that work in the division. The foundation for assuring quality is based on peer review. The practice of the division is to allow peers, i.e., colleagues who are actively engaged in the same profession, to be the arbiter of professional achievement. In other words, it is the job of the employees of the division to collectively assure quality. This process has a long history of success at Fermilab, and is a tested model in scientific research in general.

1.1 Policy

The policy of the Technical Division is to develop, document, and maintain its quality management program, so that the division can satisfy the needs of its customers.

1.2 Mission

The Technical Division mission:

“The development, design, fabrication or procurement, and testing of accelerator and detector components.”

1.3 Objectives

[1] To provide for fundamental research and development capability to support the high energy physics (HEP) programs.

[2] To provide engineering and design support for the HEP programs.

[3] To provide services of procurement, inspection, and storage of parts in support of the fabrication and testing programs.

[4] To provide high quality fabrication and repair services for conventional iron and copper magnets, superconducting magnets, detector components, and other HEP components.

[5] To provide a wide range of performance testing services for accelerator and detector components.

[6] To provide machine shop and welding services in support of the fabrication and testing programs, and to make these services available to other laboratory organizations.

[7] To apply and maintain an effective ES&H program that integrates sound ES&H practices into all division activities.

[8] To apply and maintain a quality assurance program.

1.4 Division Organization

In order to accomplish the mission of the organization, the Technical Division is organized into projects and departments. Projects are organized by task and departments are organized by function. By and large, the way that the departments interact is through doing the work of the projects. Each department accomplishes the work done in the division, and it is done to fulfill the needs of the projects.

1.4.1 Projects

Projects are organized by task. The project manager for each project is responsible for the planning and execution of specific tasks, and for coordinating the work across departmental and administrative boundaries.

Specific projects, and their leaders, are defined in the division organization chart (see 1.4.3 below).

1.4.2 Departments

The departments are organized by function, and include:

- Computing and Information Systems
- Development & Test
- Engineering & Fabrication
- Machine Shop
- Material Control
- Support (Facility Management and ES&H)

The departments are responsible for personnel, infrastructure and administrative duties, and are organized to support the projects. Functional responsibilities for the departments are defined in section 1.5 of this document.

1.4.3 Organization Chart

The organizational structure of the division is defined graphically in an organization chart that is updated by the headquarters staff and approved by the Division Head on a monthly basis. The organization chart defines lines of responsibility for the employees of the division (contract employees may not be included in the organization chart). The chart also identifies personnel assigned to serve in key roles and/or special ES&H assignments. These include identification of such positions as Radiation Monitors, Emergency Wardens, ES&H Committee Members, Building Managers, et cetera.

Each Department Head is responsible for providing the headquarters staff with updates on a monthly basis regarding organizational changes resulting from restructuring.

Organizational changes resulting from personnel leaving the division or from new personnel starting work in the division are added to the organizational chart after the personnel paperwork has been processed by TD headquarters.

The Technical Division organization chart can be accessed from the Technical Division web site. See Appendix A for the most current location of the organization chart.

1.5 Functional Responsibilities - Departments

In addition to the following responsibilities, the departments may be requested to provide their specialized services and resources to approved special projects.

1.5.1 Headquarters

The Division HQ consists of the Division Head, other managers who assist the Division Head in the administration of the division, and appropriate support personnel. HQ is responsible for the overall administration and direction of the Technical Division, and is home for the project management of various projects (refer to the organization chart for current projects).

1.5.2 Support

The Support department provides the necessary resources to support the division with Environment, Safety, and Health services, as well as Facilities Management.

Environment, Safety and Health (ES&H)

The ES&H group, composed of ES&H professionals and support staff, provides the Division Head and other line managers with advice, analysis, and technical information regarding ES&H matters to enable them to carry out their responsibilities.

Laboratory policy documents describe the roles, responsibilities, and authorities of specified personnel who are members of the ES&H group, including the Senior Safety Officer (SSO) and the Radiation Safety Officer (RSO).

Facilities Management

The Director has assigned to the division buildings and grounds to be utilized in accomplishing the division's mission. The division is responsible for the operation and maintenance of these areas in conjunction with the Facilities Engineering Services Section (FESS). Large facility maintenance activities (>$2K) are coordinated through TD Facilities Management.

1.5.3 Engineering and Fabrication

The Engineering and Fabrication department (EF) designs, manufactures, and repairs conventional iron and copper magnets, superconducting magnets, supporting hardware and tooling, detector components, and other related devices. The EF department also provides engineering, design, and technical services, which conform to appropriate safety and design standards, applicable state and national codes, and DOE contract requirements.

1.5.4 Machine Shop

The Machine Shop (MS) provides prototyping R&D and precisely machined and welded items to the division, and to other organizations laboratory-wide, in conformance with customer specifications. The MS also provides machine tool repair services to the division and makes these services available to other laboratory organizations.

1.5.5 Development and Test

The Development and Test department (DT) leads research and development projects for the division, particularly for superconducting magnets, prototype detector components and assemblies, and other advanced accelerator components. The DT department also provides a wide range of performance testing services for conventional and cryogenic magnets and related devices, for both completed prototype and production devices.

1.5.6 Material Control

The Material Control department (MC) procures, inspects, and stores parts, tooling, and non-office supplies necessary for the operation of the division. It manages the warehousing of spare magnets and related devices. It provides metrology and QC services to the division and offers such services to other organizations of the laboratory. The MC department also provides expertise in developing processes for the fabrication of purchased components.

1.5.7 Computing and Information Systems

The Computing and Information Systems department (CIS) provides support to the division for computer needs and services. CIS is responsible for the set-up and ongoing maintenance for the information systems requirements of the Technical Division (which includes training of TD personnel), and works with the Computing Division as necessary to ensure compatibility with lab-wide systems. CIS is also responsible for the security of the TD network and servers.

1.6 Functional Responsibilities/Authorities - Personnel

1.6.1 General

Commitment to quality assurance is the responsibility of all individuals in the Technical Division. Management is responsible for giving attention to quality considerations in project and production planning, and for providing adequate resources to accomplish project goals. Every employee who manages, performs, or verifies work affecting quality has the accountability, authority, and organizational freedom to:

1. Identify and record quality/safety problems, or potential problems, and to stop work until the issue has been reviewed and addressed as necessary.
2. Initiate, recommend, or provide quality/safety improvements through appropriate channels.
3. Verify the implementation of solutions and corrective actions.
4. Control processing and delivery of product and services to ensure quality standards are met.

1.6.2 Job Descriptions

The laboratory personnel office maintains basic job descriptions for each job category. Because these job descriptions are very general and since job requirements tend to change often, more specific job requirements are defined between each employee and their supervisor. This can be accomplished through informal communications as well as through the annual performance review process.

1.7 DOE Orders

Appendix I of the Fermilab/DOE contract lists the DOE Orders that Fermilab has agreed to comply with. The Directorate maintains the most current list.

As DOE orders are to be applied to the entire laboratory organization, the Technical Division is responsible for understanding and implementing the requirements of the orders listed on the contract. This is accomplished through the TD quality system, ES&H program, and work practices.

2.0 Personnel Training and Qualification

This section describes the Technical Division's training program, as well as the division's policies on job qualifications.

2.1 Policy

The policy of the Technical Division is to hire personnel who possess the appropriate level of skill, experience, and academic qualifications to support the achievement of the division's mission; and to encourage their continual development through ongoing education, training, and expanded work experience.

All Technical Division personnel (including contract personnel) are to have the appropriate training and experience to ensure that they are capable of performing their assigned work to the appropriate level of safety, efficiency, and quality. In coordinating personnel training activities, training providers should be cognizant of the fact that the Technical Division scope of work involves the collaborative effort of personnel who have widely divergent levels of education, skills, and experience.

2.2 Responsibilities

2.2.1 Division Head Responsibilities

The Division Head provides the necessary resources to ensure that Technical Division personnel are appropriately trained and qualified for their jobs. The Division Head is responsible for personnel training and qualification for members of the headquarters staff, and for maintaining records of such training and qualifications.

The Division Head is responsible for the training of HQ staff and Department Heads so that they understand the requirements described in this program.

2.2.2 Department Head Responsibilities

Department Heads are responsible for personnel training and qualifications for their scope of work or activities, and for ensuring that the training is sufficient to enable their department to fulfill the stated objectives of the division. This training includes, at a minimum, basic skills, on-the-job training (OJT), the appropriate environmental, safety & health (ES&H) training that is defined in the Fermilab ES&H Manual, and the appropriate training on the division quality system and objectives.

Department Heads are also responsible for maintaining adequate records of the training (see section 2.8).

Refer to Appendix A for the most current location of the Fermilab ES&H Manual.

2.2.3 Line Management Responsibilities

Line management is required to be familiar with Laboratory policy on ES&H responsibilities as set forth in the Fermilab ES&H Manual.

Line management is responsible for ensuring that personnel training and qualification requirements are met for the assigned scope of work and activities. This includes Technical Division personnel and those personnel from outside the division who are under the direct supervision of line management.

2.3 Personnel Specific Positions (Job Openings)

Qualifications for specific job positions (job openings) are spelled out in personnel requisitions to ensure that only qualified candidates are considered for available positions. These personnel requisitions require a level of detail listing specific qualifications, required experience/skills, formal education, or any other job related requirement, and must be consistent with Fermilab Employment (personnel) requisition requirements, policies, and practices.

2.4 Education Qualifications

The education that is required for obtaining a university/college degree (or other professional certification) constitutes qualification for working within the discipline in which the degree was granted. Equivalent work experience and technical activity in a related discipline may also constitute acceptable qualifications.

2.5 Individual Training Needs Assessment (ITNA)

To ensure that training needs are maintained at an appropriate level, a training needs assessment is required for each employee on an annual basis or whenever a change in job assignment or job hazards occurs.

The annual training needs assessment is conducted during the performance review process. It includes a review of employee training needs with respect to the work the employee is expected to perform or hazards that the employee would be exposed to in the normal performance of the assigned job.

2.6 Training Plan

An output of the performance review is a plan to implement the training needs of each employee within the division. Some training needs may be coordinated through the headquarters office so that training can be provided division-wide (e.g. ES&H training). On-the-job training is coordinated through the Department Head and area supervision.

2.7 Specific Job Related Training

For work that does not require an accredited university/college degree or other professional certification, implementing management is responsible for developing training that is appropriate to the complexity, hazard, and programmatic significance for their scope of work or activities.

When it is determined that an employee needs specific job related training in order to effectively and efficiently carry out duties that are assigned, training will be made available to the employee. Where possible, in-house training will be provided to ensure that an appropriate level of skills, knowledge, expertise, and experience are available to accomplish the stated mission and objectives. Training may come from several sources such as mentoring, or as provided by physicists, engineers, supervisors, lead personnel, consulting firms, quality assurance personnel, Environment Safety & Health (ES&H) personnel, approved formal organizational training agents, or other sources. When in-house training is not practical or adequate, outside sources will be used to provide training.

2.8 Training Records

2.8.1 The TRAIN database is the official record for all ES&H training. ES&H training is recorded in the TRAIN database by ES&H personnel.

2.8.2 Records of on-the-job training (not related to ES&H) are maintained at the department or group level. The responsible group determines the method of record keeping, such as TRAIN. The method must allow for easy retrieval and review of the records.

These records may be limited to recording when the training was complete on the Performance Review form. It is not a requirement to maintain these records "real-time". It is sufficient to update the training records for the previous year during the performance review.

2.8.3 Records of training from attending formal courses are maintained by the individual taking the training. A note should be made on the performance review form that the training took place, but the individual maintains the official certificate.

2.8.4 Individuals who have been operating a piece of equipment for more than one year are considered to be "grand-fathered", and as such a record stating that they are trained does not need to be maintained.

3.0 Quality Improvement

This section describes the methods used by the Division to continually improve.

3.1 Policy

The policy of the Technical Division is to continually improve in all areas and activities for which it is responsible.

3.2 Reporting Deficiencies

All levels of personnel in the Technical Division are responsible for quality and are encouraged to promptly report conditions adverse to quality such as deviations, deficiencies, failures, defective items or processes, personnel safety concerns, and non-conformances to the appropriate level of management for corrective action. Employees closest to the daily operation or activity, i.e. line workers and line supervision, are in the best position to understand and report nonconforming conditions and are asked to participate in quality improvements to meet the needs and objectives of the division. A strong emphasis is also placed on fostering a "no-fault" attitude toward the person making the report. Division management believes that improvements will not take place if we "shoot the messenger", and making mistakes in the process of learning new things helps us to accept new ideas and improve.

3.3 Suggesting Quality Improvements

Improvement not only occurs when we identify and correct problems, but also by adding controls to prevent problems from occurring in the first place. Every employee in the division has the authority and responsibility to think creatively about *preventing* problems from occurring, and to voice these ideas to supervision/management. It is supervision/management's responsibility and obligation to listen to these ideas, and to appropriately act on them with the employees. In this effort it is very important that we think as a system, i.e. changes we make can have negative impacts on other groups. A change that makes a local process safer or easier may add work to another process in another group. It is important to pay attention to the entire system when making "improvements".

3.4 Performance Analysis

3.4.1 Supplier Performance

Supplier performance problems are identified and reported through the mechanism of Quality Control Reports (QCRs), generated by the Material Control Department's Quality Control group for items such as incoming parts and assemblies. These reports are reviewed and approved by the responsible authority/physicist (or designee) of the area or activity in which they will be used and by the Material Control Department Head (or designee). The review covers problems that may have significant programmatic effect or risk factors affecting cost, schedule, ES&H (personnel safety), or configuration. The appropriate disposition is given, i.e. scrap, return to vendor for replacement, rework at vendor, rework in house, or use as is. These reports are reviewed for supplier performance problems or trends and are used as a basis for cause analysis and necessary corrective action.

3.4.2 Work Process Performance

Discrepancy Reports have been developed and implemented to document problems such as deviations, defects in materials or processes, failures, malfunctions, and/or non-conforming conditions during fabrication, assembly or testing.

The responsible authority of the activity or area of occurrence reviews these discrepancy reports for technical evaluation, cause determination, disposition (corrective action), and preventive action recommendation. The appropriate personnel implement the corrective and preventive actions.

Process Engineering performs a review of these reports to ensure that reports are completed properly and that preventive action is adequate; the QA Manager may also recommend follow up corrective/preventive action or verification/validation as required. These discrepancy reports are used as a basis for trends, cause analysis, and/or lessons learned.

3.5 Design Reviews

At the conclusion of each design phase of a project a formal, documented, systematic, internal design review is conducted to ensure that the final design and supporting data will meet design code requirements and standards. The design review should identify and anticipate problem areas, inadequacies, initiate corrective action, and include representatives of all functions affecting quality as appropriate to the phase being reviewed. These formal design reviews are used as a basis of assessing design reliability, ES&H, safety issues, quality problems, design improvement, and design practicality.

3.6 Management Assessments

Management assessments are conducted following procedures established in the TD Self-Assessment Program. These audits cover environment, safety & health as well as quality assurance requirements. Results from these activities are used as a basis for cause analysis or trending and the basis for continuous quality improvement from lessons learned.

3.7 Performance Review

The Laboratory Services Section requires annual performance reviews for all employees who have at least six months' service with the laboratory. The performance review allows management to assess each employee's effectiveness, to discuss recommendations for improvement as appropriate, and to jointly establish future performance goals and training.

3.8 Individual Training Needs Assessment

To ensure that training needs are maintained at an appropriate level, a training needs assessment is required for each employee on an annual basis or whenever a change in job assignment or job hazards occurs. These training assessments are intended to promote continuous quality improvement by ensuring that the division's work force remains adequately trained and qualified. Section 2 of this document describes the division's training program.

3.9 Grassroots Safety Committees

Each department in the Technical Division has an employee grassroots safety committee. The primary purpose of these committees is to provide a forum for non-supervisory employees to identify and discuss unsafe conditions and practices in their workplace. These ideas for improvements are appropriately documented and sent to departmental management for assessment and action. This process has proven to be a very effective mechanism to help the division improve.

A "Guidance Document" was issued on 5/13/1999 that describes in more detail the overall process. Refer to Appendix A for the most current location of this memo.

4.0 Documents and Records

This section describes the methods used by the division to control the documents and records that are part of the quality system.

4.1 Policy

The policy of the Technical Division is to maintain adequate documentation and records to ensure quality requirements are met, while recognizing the objective of minimizing paperwork and overhead cost.

4.2 Definitions

Controlled document - any written or recorded information (other than data and records) that:

- is subject to change; and
- effects the quality of a product/service if the most current issue is not used.

A controlled document:

- Is approved for use by an authorized approver;
- Has a traceable revision history; and
- Has a controlled distribution.

Quality Record - The certificates, forms, worksheets, tables, documents, orders, charts, memos, meeting minutes, and other records completed or generated throughout normal business operation. These records demonstrate conformance to specified requirements and effective operation of the quality system.

Readily Retrievable -Stored in a location and filed/indexed in a manner that allows the record to be obtained within one working day, or less, of moment of request for the record.

4.3 Responsibilities

4.3.1 Headquarters

TD Headquarters is responsible for maintaining documents and records related to the management of the Technical Division. These include such documents as division personnel files, hard-copies of ES&H self-assessment records, hard-copies of Significant and Reportable Occurrences (formerly 5000.3B reports), as well as information on budget, signature authority, security, and foreign travel.

4.3.2 Department Heads & Departments

Each Department Head is responsible for defining roles and responsibilities within their organization for the release, revision, and distribution of all documents and records at a level commensurate with the scale, cost, complexity, hazards, and programmatic significance of the work being documented.

Each department is responsible for documents and records associated with their activities, and shall define and document a records management system for their scope of work.

4.3.3 Quality Assurance Manager

The QA Manager is responsible for assisting the division with the creation and maintenance of its quality system documentation.

4.3.4 Line Management

Line management is responsible for creating and maintaining the documents and records that describe products, services, equipment, software, procedures, and essential transactions at a level commensurate with the scale, cost, complexity, hazards, and programmatic significance of the work being done.

4.4 Document Control

[1] Controlled documents are developed to ensure that complex work or hazardous conditions have the necessary controls to achieve personnel safety and to fulfill the Fermilab and Technical Division mission.

[2] Controlled documents are reviewed, approved, and released by authorized personnel before they are distributed to and used at the location where the prescribed activity is performed.

[3] Unless otherwise stated in specific procedures, authorized personnel may make hand-written changes to controlled documents as a *temporary change* only. The altered document should go through revision control as soon as is practical.

[4] The distribution of controlled documents is managed such that a distribution list is maintained by the issuing organization to ensure that all issued documents contain the most current information. Every effort is made to minimize hard-copy distribution, and instead provide access via the computer network.

The following represents a listing of the types of documents defined as controlled documents for the Technical Division:

[1] TD Policies and Procedures Manual (this includes the division quality program and its related documents)
[2] Departmental and project quality programs/plans
[3] Departmental procedures, work instructions, and specifications
[4] CAD drawings

4.5 Records Management

The proper maintenance of records is important for the successful operation of the division. Records management begins with the creation of records. The creation of the appropriate records by the appropriate people is critical for understanding what we did in the past, as well as for figuring out where we stand today. *We must view the work of maintaining records as important as the work for which the record is about.*

Records can normally be categorized as either administrative or technical. The main focus of Technical Division records management is on the technical records. The general policy of the division is to maintain technical records of a device for as long as the device is in service or has a possibility of being placed into service.

Records can come in two formats, hardcopy and electronic, and our records management program must be able to handle both types. Defining how we handle paper records is, in many ways, simpler than defining how we handle electronic records. Electronic records have the added complexity of platform and software dependence, which over time can cause some records to be irretrievable. In choosing an electronic records management system future migration needs must be considered. As platforms become obsolete critical data must be migrated to current systems.

Retention and accessibility of records can generally be described in the following ways:

- Records are retained in the immediate work area. Most people have access to them;
- Records are retained onsite, but not in the immediate work area. Fewer people have access to them;
- Records are retained in offsite storage. Minimal access is provided.

It should be noted that the main offsite storage is only for paper records, but that retention and accessibility issues can be applied to both paper and electronic records.

Due to the fact that the content and format of records vary greatly from department to department and project to project, each department or project is responsible for defining and documenting a records management system for their scope of work. Each system should take into account the following guidelines:

- The "major" record types should be defined, i.e. the ones critical to the mission of the department or project;
- The format(s) for each record type should be defined. Electronic records should include the appropriate technical details such as platform and software. For records that are in both paper and electronic forms, the primary form should be defined;
- A responsible authority for each record should be defined. Job titles or group names are most appropriate;
- The storage location for each record type should be defined. Records should be stored in a way that they are readily retrievable and stored in an environment that protects the records from damage, deterioration, or loss (archived records are not subject to the "readily retrievable" requirement);
- Retention and accessibility practices for each record type should be defined.

Appendix A contains references to various records management tools that are currently in use in the division.

The Technical Division's practice is to follow the Fermilab Records Management Program either when asked, or when necessary to move records to or from the offsite storage (i.e. archiving). Refer to Appendix A for the most current location of this program.

5.0 Work Processes

This section describes the methods used by the division to assure the quality of the processes used to conduct the business of the Technical Division.

The Technical Division organization practice is such that work processes occur in the departments and are defined in the department. The sections below provide an overview of each topic.

The central tool used by the division to control work processes is the "traveler". As a tool the traveler serves many functions, and these functions are described in the sections below.

5.1 Policy

The policy of the Technical Division is that work processes be well thought out, appropriately documented and reviewed, and that they be carried out by competent and effective workers.

5.2 Hazard Analysis

Each Department Head is responsible for developing the means for analyzing work processes to determine if the work is sufficiently complex or hazardous to be performed to written procedures (see FESHM 2060 "Hazard Analysis for Fermilab Employees" for more details on hazard analysis). The Department Head is also responsible for developing a methodology for the preparation, review, and approval of procedures which is commensurate with the complexity, hazard potential, and ES&H impact.

5.3 Production Process Control

The EF Department Head, in conjunction with Project Managers, is responsible for ensuring that production processes are carried out under controlled conditions. When planning the production processes, the following are considered:

- All applicable government and laboratory safety and environmental regulations/policies.
- Use of travelers (or other such work instructions) to document the methods of production. These should be used when the absence of such procedures could be adverse to quality.
- Defining suitable equipment and work environment to ensure quality.
- Defining and conducting suitable maintenance of equipment to ensure continuing process capability.
- Defining the criteria for workmanship in the clearest practical manner. Examples of this are work instructions that document tolerances for process

parameters, samples or pictures of "quality" product, samples or pictures of poor quality or failure modes to look for.
- Level of education and experience required for production operators.
- Training needs for production operators

5.4 Travelers

A system of travelers is used to define the sequence of fabrication, inspection, and testing to be performed as appropriate for the division's scope of work. Witness/Hold points are designated in travelers at a turning point or important juncture of the fabrication. Travelers provide for sign-off by qualified personnel and are dated at the completion of each fabrication sequence, welding operation, and inspection/test procedure by designated inspection/test personnel, fabrication personnel, or welding personnel to assure completion, date completed, and sequence of required operations.

The Process Engineering Group within the Engineering & Fabrication Department is responsible for the implementation and maintenance the traveler system.

While travelers are used for all major production runs, and most "onesy-twosy" repairs, travelers may not be used in all situations. For example, it is recommended that travelers are used during the research/prototype phase of a project, but they are not a requirement. The Project Manager (or appropriate designate) decides whether or not to use travelers during the research/prototype phase. *However, once a product is approved to production, a traveler must be used. This means that it is very important that project planning includes the allocation of the proper resources to implement and maintain travelers for production*.

In the event that travelers are not used for the fabrication or rework/repair of a production device, it is still a requirement to maintain adequate as-built records. However, completing these records *after* the device has been built can lead to incomplete or incorrect information, and so *these records should be created as work is performed on the device.*

5.5 Identification, Traceability, and Test Status

All finished components are identifiable with names and serial numbers that are located on the unit and it's accompanying traveler(s). Serial numbers are marked on the unit according to a project specific serial number specification.

Sub-assemblies are identified appropriately. The method of identification depends on the sub-assembly and the scope of the label. Some possible identification methods include:

- A stamp or label containing pertinent information is placed on the device;
- A tag containing pertinent information is affixed to the device;
- Serial numbers may be assigned if the device is sufficiently complex (the use of a traveler to fabricate a sub-assembly usually means that the sub-assembly is assigned a serial number);
- Sometimes a sub-assembly will have no physical label, in which case we rely on people, and the corresponding drawings, to identify the parts.

The lot/batch/serial numbers of the parts going into the unit are recorded on the traveler, and so it is the traveler that is the main document used for traceability.

While it is being fabricated, the test status of the unit is identifiable using the accompanying traveler, i.e. the traveler will show how far along the unit is in the assembly and test process, as well as the results of the QC checks. When the unit is completely assembled, it is tagged showing the test status.

5.6 Control of Non-conforming Product

Most fabrication-related nonconformances are due to either a test result being out of specification or a process not working as was planned. At the point of a discrepancy or nonconformance the first-hand observer initiates a Discrepancy Report using the Discrepancy Report instructions as a guide. The DR is routed to Process Engineering personnel, and to the Project Engineer. The Project Engineer analyzes the data and dispositions the item. If the item requires reworking then instructions for the rework are usually written in the DR. If the rework is sufficiently complex then a special rework traveler may be issued and used. After rework is completed the item is retested against the specification, and is dispositioned accordingly.

5.7 Materials Storage

In the Technical Division the Material Control Department is responsible for the storage of most work process equipment, materials, completed magnets, and other accelerator and detector components. The Material Control Department Head is responsible for establishing, documenting, communicating, and carrying out practices and procedures that ensure that items are stored and maintained to prevent damage, loss, or deterioration.

Other departments and groups within the division maintain small inventories. The group maintaining the inventories is responsible for ensuring that items are stored and maintained to prevent damage, loss, or deterioration.

5.8 Maintenance

Properly functioning equipment is critical to the success of the Technical Division. There are certain pieces of equipment for which there are specific preventive maintenance activities (e.g. oiling of motors, safety inspections, or third party maintenance contracts), but by in large most equipment used within the division is run-to-degradation. The success of this methodology relies on the continuous monitoring of equipment, systems, and operations. The goal is to catch problems early, so that a small problem can be fixed before it turns into a large and expensive problem. The operators of the equipment are in the best position to be able to identify problems at the earliest stages, e.g. hearing "funny" sounds or seeing more oil spilling than usual.

Each department maintains a list of all equipment owned by the department (referred to as a "Master Equipment List"). This list, or other such documentation, should define the planned maintenance activities, as appropriate. Part of the work to create and maintain the master equipment list should be to identify the critical parts for which the department should maintain adequate spares. The decision to maintain spares is made by comparing the risks involved if the parts had to be ordered each time to the cost of keeping the spares in inventory, i.e. a cost-benefit analysis.

5.9 Readiness Reviews

Readiness reviews are conducted on certain activities to ensure that the proposed activity has been adequately planned and work prerequisites satisfied. The decision to require readiness reviews is principally based on the scope and risk of the project; i.e. a "large" project that is considered to have a high risk will require a formal review, while an activity that is considered to have a low risk may not require a review. For activities requiring a review, an individual is identified as the principal manager of the activity and is referred to here as the Project Manager.

The scale, complexity, number, and timing of readiness reviews is commensurate with the scope of the proposed activity and is determined by the Project Manager in conjunction with the Division Head. For Plant Projects, provisions and requirements for readiness reviews are addressed in the project's Conceptual Design Report, Technical Design Report or Project Management Plan, whichever is applicable.

Readiness reviews can be conducted as independent or dependent reviews. Dependent reviews are conducted internally to ensure that a specific group is ready to begin an upcoming activity (e.g. E&F internally reviewing their ability to begin working on a magnet). Independent reviews are described in the following paragraph.

Independent readiness reviews are coordinated by the Project Manager and are attended by qualified individuals or groups other than those associated directly with the planned activity to ensure an independent review is conducted (note: the term "attended" does not necessitate a physical meeting; the format can be a telephone/video conference, or other such remote conferencing). Results from the review are used as the basis for assessing whether the activity planning has been accomplished in a complete and thorough manner and that issues such as resource requirements, personnel qualifications, ES&H matters, acceptance criteria, and quality control and assurance measures have been adequately considered and addressed. A written summary of the readiness review, including comments, concerns, and recommendations, should be provided to the Division Head and others as appropriate. The Project Manager is responsible for addressing issues arising from the readiness review and for providing adequate follow-up.

5.10 Device Data Management

A major portion of the work done in the division is the fabrication and repair of magnets used in the accelerator. Due to the volume of devices passing through the division, along with the change in division personnel, there is a need to document the work done on each device. The "device data management" system aids the division in tracking the status of every device, as well as to maintain at least a portion of our "institutional memory".

The departments that work directly on the devices, i.e. Material Control, Development & Test, and Engineering & Fabrication, use the device data management system. As work is done to the device a log is entered into the system, and its status is updated as necessary (e.g. recording that the measurement of the device has been completed in IB1 and that the appropriate authority has classified the device as "ready to use").

Further details about the system are found in the document *Device Data Management System TD-2030*.

5.11 Infrastructure

The quality of the infrastructure used by the division to fabricate and measure devices has a direct impact on the quality of the devices themselves. The proper design, fabrication and maintenance of our infrastructure is critical to the successful fulfillment of our mission. The same principles that are applied to ensuring the quality of the devices are applied to the infrastructure used to fabricate and measure the devices. It is for this reason that the scope of the quality system includes all infrastructure.

Infrastructure is typically used for either magnet fabrication (e.g. tooling) or magnet measurement (e.g. cryogenic, power, data acquisition and control systems).

Tooling is the work of the Engineering & Fabrication department and is typically managed with the same methodology as magnets, with the exception that travelers are not used to fabricate tooling. Tooling is also part of the maintenance program (see section 5.8)

Measurement infrastructure is the work of the Development & Test department. Quality is ensured primarily through adequate design planning. Care is taken to ensure that systems are standardized as much as possible, as well as flexible enough to be able to measure various devices, as appropriate (i.e. multiple configurations). Configurations must be adequately documented so as to allow for easy setup the next time the configuration is used. The proper methodologies in fabrication, commissioning, operation and maintenance (see section 5.8) are also important for ensuring quality.

6.0 Design

This section describes the methods used by the division to assure the design quality of devices designed by the Technical Division.

The term "device" is used in this section to mean anything that is designed in the Technical Division. This includes all accelerator and detector related devices, tooling, cryogenic and power systems, as well as data acquisition and control systems.

6.1 Policy

The policy of the Technical Division is to ensure that designs perform as intended while minimizing cost. This is accomplished by having competent people incorporate sound engineering and scientific principles and appropriate technical standards into designs.

6.2 Requirements and Responsibilities

6.2.1 Introduction

Within the division, procedures and practices are established to ensure that sound engineering principles and appropriate standards are incorporated into all design work. These procedures describe how design and reliability requirements are established, as well as the translation of these requirements into design outputs such as specifications, drawings, procedures, and instructions. Design changes are effected as required to improve the quality, efficiency, or performance of a design and are subject to approval by the original design individual or organization or a qualified alternate.

It is the responsibility of the Heads of the Engineering & Fabrication (EF) and the Development & Test (DT) departments to establish sound engineering procedures, practices, design controls, and standards.

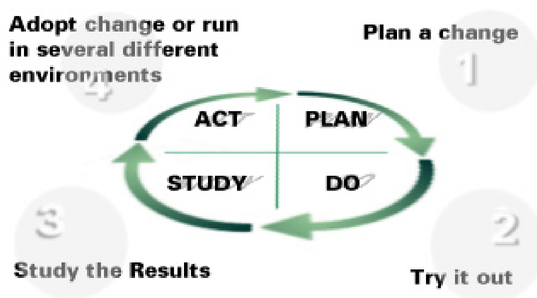
Project managers decide the degree of formality for the design process for their project, and so the overall design process varies by project. It typically follows the long-standing principles of the "scientific method", and can be described as follows:

1. <u>State the issue</u> - this is the work of defining the task(s) to be completed.
2. <u>Form a Hypothesis</u> - this is the work of defining the criteria that the device needs to meet, and then defining how the device is going to meet those criteria.
3. <u>Observation and Experimentation</u> - this is the work of building prototype devices (and components) and testing them against the hypothesis.

4. Interpretation of Data - this is the work of analyzing the data as compared to the hypothesis.
5. Draw a Conclusion - this is the work of either:
   - modifying the design of the device to more closely model the criteria; or
   - changing the hypothesis to match experimentation results; or
   - approving the design and moving on to the next phase.

This process is iterated until the desired performance of the device is achieved, or until it is concluded that the hypothesis does not work at this time.

In the world of quality assurance, this process is know as the "Plan-Do-Study-Act" process (first developed by Shewhart and then later it became known as the "Deming Wheel").



6.2.2 Design Input

Design input may come from many sources, which includes performance expectations, cost requirements, schedule constraints, material requirements, safety, and conceptual or research design reports and drawings. These inputs are defined by the "customer", which may be a Project Manager, TD research personnel, the Beam's Division, a project collaboration, or another HEP laboratory.

6.2.3 Design Process

The design process translates design inputs into design output documents. Design practices are communicated through proper education, training, and work experience, and may not be formally documented. A graded approach is used when designing components. Depending on the size, scope, and risks of the task, the process may range from being very informal (e.g. mostly verbal communication - "proof of concept" activities) to being very formal (e.g. mostly written communication). There is a wide range of complexity and difficulty in design work, and it is this complexity which drives the formality and rigor of the design process.

Part of the design process includes the use of certain industry or laboratory specific standards or codes. These standards aid the designers in developing the most appropriate design. A list of some of the most frequently used standards is found in Appendix A.

6.2.4 Design Output

The main outputs of the design process are the drawings and specifications for the device. Other outputs include the information and documentation needed to support other processes such as procurement (e.g. parts lists and approved vendors), fabrication/assembly (e.g. travelers), inspection/testing (e.g. travelers), installation, and maintenance.

Each department is responsible for defining and documenting the methodology used for processing the initial release of drawings within their scope of work.

6.2.5 Design Verification

Prior to implementation, design verification is conducted at a level commensurate to the scope and complexity of a design to ensure that the design conforms to design requirements, adheres to applicable codes and standards, and minimizes hazards to operating personnel and the environment. Design verification may include design reviews, alternate calculations, and/or qualification testing under conditions simulating both operating and adverse conditions.

Design reviews are performed by qualified individuals or groups other than those who performed the original design to identify and anticipate problem areas and inadequacies, initiate corrective actions, and assess issues affecting safety and quality as appropriate to the design being reviewed. Results from this process are used as a basis for assessing design reliability, ES&H, safety issues, quality problems, design improvement, and design practicality.

6.2.6 Design Validation

Designs are validated through the testing of the complete prototype system (or subsystem) during and after assembly. It is the role of the Measurement and Test Facility (part of DT) to complete the validation testing. Data gathered by MTF is analyzed to determine whether or not the device will perform as required.

Again, a graded approach is used when validating designs. Depending on the size, scope, and risk of the task, the prototype build may not be tested at MTF.

6.2.7 Design Changes

Depending on the scope of the project and the magnitude of the design change, design changes may be handled in various ways. If it is a small project and/or the design change does not have a major impact on the device or on other devices and systems, then design changes may be handled rather simply. This would entail following the established protocols for updating the drawings, parts lists and travelers (if travelers are being used).

If it is a large project and/or the design change has the potential to cause a major impact either on the device or on other devices and systems, then a "configuration review" is completed prior to the implementation of the change. A configuration review ensures that:

1. The change is necessary;
2. The consequences are acceptable;
3. The change has been properly documented; and
4. The plan for the implementation of the change into documents, hardware, and software is satisfactory.

Each department is responsible for defining and documenting the methodology used for processing changes to drawings within their scope of work.

7.0 Procurement

This section describes the methods used by the division to assure the quality of goods and services purchased by the Technical Division.

7.1 Policy

The policy of the Technical Division is to ensure that items and services provided by suppliers meet the requirements and expectations of the end-users at minimum cost.

7.2 Requirements and Responsibilities

7.2.1 Procurement

All procurement activities are performed in accordance with the *Fermilab Procurement Manual*, the *Fermilab ES&H Manual*, and the *TD Policy and Procedures Manual* (specifically TD-4100).

<u>Short Orders, Procard, Stock Room and Petty Cash purchases</u>

Any TD employee (with the appropriate authorization) may make purchases using short orders, procard, the FNAL stock room or petty cash. Individuals making purchases using these methods are responsible for following established procedures/protocols (including suspect/counterfeit items - see 7.2.5), and for maintaining the appropriate records of the transaction.

<u>All other Technical Division Procurements</u>

All other Technical Division procurements are routed through the Material Control Department for processing.

The Material Control Department is responsible for creating and maintaining the appropriate records for procurements to ensure that proper specifications, drawings, or other unique requirements are specified and supplied.

The Material Control Department is also responsible for tracking procurements and for ensuring that all necessary signatures and ES&H approvals are obtained.

<u>Acquisitions for other Divisions/Sections</u>

When the Material Control Department provides acquisition services to other divisions and sections of the laboratory, the division/section that is asking for the service provides the appropriate budget codes and approvals to Material Control.

7.2.2 ES&H and NEPA Significance

All purchase requisitions, task order requisitions, and other procurements are reviewed for potential ES&H and NEPA significance as mandated by the Fermilab ES&H Manual chapters 5010 and 8060. Material Control personnel may perform an initial ES&H review for pre-qualified items, while TD ES&H personnel perform additional ES&H and/or NEPA reviews, as appropriate. ES&H and NEPA reviews are conducted as per processes defined in the TD Policy Manual, TD-4100.

7.2.3 Supplier Evaluation and Award

Contracts are awarded to suppliers based on their ability to meet subcontract requirements. These requirements are appropriately defined and documented, and include specific quality assurance requirements. Topics that are usually evaluated include, but are not limited to:

- Quality assurance measures Cost Work history
- Ability to meet all requirements Financial resources

Solicitations for bids or proposals can be structured in multiple ways. Except for sole sourcing, each method is designed to promote full and free competition, as well as to fulfill all the needs of the laboratory. On occasions where there is only one viable source, sole sourcing is available. A brief description of the various methods follows:

1. "Request for Quote" (RFQ) - this method is used when the materials or services to be purchased can be described in a clear and concise manner (i.e. with only drawings and/or specifications). The award is given to the lowest responsible bidder, usually decided by Purchasing.
2. "Request for Proposal" (RFP) - this method is used when a technical proposal is required for determination of the most responsive and responsible bidder for the stated requirements. The award decision is made by Purchasing as well as the appropriate technical personnel. The "formula" used to award the contract may or may not be determined prior to receiving bids.
3. "Sole Source" - this method is used when one source has exclusive capability to adequately perform the work within the time required and at reasonable prices.

Experience has proven, in general, the earlier that both the TD Material Control and the Business Services Procurement departments are involved in supplier selections, the easier and more efficient this process will be. Both of these groups have expertise in identifying and selecting the best suppliers for doing work for the laboratory.

More details regarding supplier selection and the procurement process are documented in the Operating Procedures of the Fermilab Procurement Manual. See Appendix A for the most current location of the manual.

7.2.4 Supplier Development

Good communication between the TD and its suppliers is critical to ensuring the success and improvement of both groups. This is most commonly done through the use of Quality Control Reports (refer to section 3.3.1 for more details on QCR's).

Development work may include the training of the supplier on the use of travelers and other processing/fabrication tools and methods. This transfer of knowledge helps suppliers to improve their processes as well as assure that the requirements of the TD are met.

Part of the development of suppliers also includes proactive communication and involvement between the TD and the supplier. This type of development includes telephone monitoring as well as "vendor visits".

7.2.5 Suspect/Counterfeit Items

The Directorate and/or Business Services Section is responsible for identifying current Suspect/Counterfeit Items (S/CI) issues, and for communicating the appropriate information to the Technical Division. As appropriate, every individual who makes purchases for the Technical Division is responsible for understanding issues relating to S/CI, including:

- the parts/manufactures that are a concern; and
- the methods of preventing the procurement/use of S/CI

The most recent location for the DOE web site on suspect & counterfeit items can be found in Appendix A.

8.0 Inspection and Acceptance Testing

This section describes the methods used by the division to assure the quality of the fabrication and testing of high-energy physics components.

8.1 Policy

The policy of the Technical Division is to ensure that all items, components, and services meet the specified requirements. This is verified through the use of inspection and acceptance testing.

8.2 Requirements and Responsibilities

Department Heads are responsible for providing for inspection and acceptance testing equipment, methods and procedures as appropriate for their scope of work

Inspection and acceptance criteria are primarily defined in drawings and engineering specifications. Travelers state certain criteria, but these criteria are taken from the appropriate drawings and engineering specifications. Procurement documents may also be used to define certain inspection and acceptance criteria.

The equipment used for inspections and tests is required to be calibrated and maintained to ensure accuracy. Records of calibration are maintained by the group responsible for the calibration.

8.3 Receiving Inspection and Testing

The Technical Division Material Control Department is responsible for the verification of conformance of purchased items to procurement documents for non-standard items such as machined piece parts, components, and assemblies built to laboratory designs, and other unique purchased items. The Material Control Department is also responsible for the methods, procedures, and required documentation related to the inspection and testing. Verification is completed in the form of receiving inspection and/or in-plant surveillance (source inspections) which are performed by qualified personnel, test equipment, and methods. The Material Control Department is responsible for maintaining objective evidence of such qualifications and adequate records for all inspections and tests.

8.4 In-Process and Final Inspection and Testing

A system of travelers is used to define the sequence of fabrication, in-process and final inspection and testing to be performed on a device. The inspection and testing is completed using appropriately documented procedures and qualified personnel (refer to section 5.4 of this document for more information regarding the traveler system).

While travelers are used for all major production runs, and most "onesy-twosy" repairs, travelers may not be used in all situations. In the event that travelers are not used, it is still a requirement to develop adequate inspection and testing methods and to maintain records of all inspection and testing.

It should be noted that "final" inspection might also include performance measurements, such as taking magnet measurements at the Measurement and Test Facility of the Development and Test department or detector component measurements on a cosmic ray stand. The Project Manager is responsible for deciding when performance measurements are necessary. When performance measurements are required, the testing requirements must be appropriately defined, documented, and communicated to measurement personnel. Testing results must be appropriately documented and communicated back to the customer.

8.5 Measuring and Test Equipment Calibration

Calibration in the Technical Division can occur in two ways:

1. Equipment is tested with a reference, and the equipment settings may be adjusted to match the standard. After the calibration the equipment has a known accuracy.
2. Equipment is tested with a reference, and the equipment cannot be adjusted to match the reference. In this case, the calibration results are used to adjust the raw data from the equipment when it is used to measure product.

All equipment which effects product quality (or is used to make a decision which effects product quality) is calibrated at prescribed intervals, and is appropriately identified with its calibration status. In general, calibration reference standards are traceable to NIST or other national/international organizations. If no national standard exists, then the basis used for calibration is appropriately documented.

Department Heads are responsible for analyzing their work process measuring and test equipment to determine the appropriate calibration requirements. Department Heads are also responsible for developing an effective program for the necessary calibration activities.

The Material Control department provides calibration services for the calibration of mechanical instruments and equipment used by the division. And although Material Control performs the calibration service, and may recommend the frequency with which equipment should be inspected and recalibrated, the Department Head whose organization owns the equipment is responsible for ensuring the equipment is properly maintained and calibrated.

9.0 Quality Assessment

This section describes the methods used by Technical Division to assess the adequacy, implementation and effectiveness of the Technical Division's quality system.

Within the Technical Division there are three types of assessments: *management*, *worker* and *independent*.

9.1 Policy

The policy of the Technical Division is to regularly assess the division’s effectiveness in meeting it’s objectives, goals, and compliance to orders and regulations. This is accomplished using the Technical Division Self-Assessment Program.

The TD Self-Assessment Program describes the formal management (and independent) assessment process for the division. Highlights of the program, as well as other assessment methods (more informal) that the TD uses are described in the section below.

9.2 Management Assessments

Management assessments are dependent internal assessments because the people, i.e. managers, who are doing the assessment have direct responsibility for the area being assessed. This type of assessment is very important for assuring that the entire division is working to assure the quality of our products.

9.2.1 Division Head Assessments

Each calendar quarter the Division Head conducts a meeting with a different Department Head and other representatives from the Division to assess specific areas of functional responsibility and performance objectives within that department. An agenda of topics to be reviewed is normally distributed prior to the meeting. Topics that are typically reviewed include: employee training status, self-assessment pending issues and findings status, ES&H policies or procedures to be implemented or discussed, schedule requirements, budget issues, administrative policy or procedural issues, quality issues, and training.

9.2.2 Department Head Assessments

Department Heads are responsible for the assessment of the activities within their scope of work and to provide first-hand assessment concerns to the Division Head for review, suggestions, recommendations, and a plan of appropriate corrective action. Department Heads periodically meet with their crew chiefs, line supervisors, and lead personnel, either individually or as a group, to assess progress and performance objectives and to implement policy direction from the Division Head.

9.2.3 Line Supervisor Assessments

Line supervision is responsible for the daily operations of the division. Line supervision or lead personnel regularly interact with their personnel to assess the scope of their activities and performance objectives. These conversations provide for first-hand assessments and recommendations from line personnel to improve on existing procedures, policies, scope of work, and other line personnel concerns.

Suggestions and recommendations are presented to the appropriate levels of management for consideration or clarification and to enable management to take the appropriate necessary corrective action commensurate with the programmatic significance or importance of the problem.

9.3 Worker Assessments

Worker assessments involve the worker routinely comparing the processes and products to defined expectations. Worker assessments are critical to the proper functioning of the division. As stated in section 3, employees closest to the daily operations are in the best position to understand deficiencies, provide feedback on them, and to make recommendations for improvement. The practice of analyzing a task before starting it aids the division in preventing problems.

Examples of methods to provide feedback include Discrepancy Reports (see 3.4.2), Traveler Revision Requests, Grassroots Safety Committees (see 3.9), and daily interaction with supervision (see 9.2.3).

9.4 Independent Assessments

Independent assessments are conducted by a person (or a group or people) who is not directly responsible for the area being assessed. These assessments can be conducted by people from within or from outside the Division. Examples of these are assessments performed by the QA Manager or SSO on departmental or project quality/ES&H programs, "OSHA" inspections by TD ES&H inspection teams, Tripartite assessments, or assessments conducted by the DOE on TD activities.

Independent assessments focus on *systems*, and use fact-based observations as a basis for drawing conclusions about the health of the organization's systems and reporting these conclusions in a way that can be used by line managers to initiate long-term improvement.

Technical Division assessments gather information from management systems on:

1. *Adequacy* - do the systems as they are designed have the potential to succeed?
2. *Implementation* - are the systems being implemented as designed?
3. *Effectiveness* - are the systems achieving their intended results?

Findings, concerns, and recommendations generated as a result of independent assessment activities are typically reported in writing to the person responsible for the area being assessed. Findings are also entered into the laboratory ES&H tracking database (ESHTRK - refer to Appendix A for the most current location) and are assigned to the appropriate person who is responsible for the corrective actions. Tracking of findings to closure occurs through the mechanism of the Quarterly Report to the Director describing self-assessment activities. In preparing the Division's report, Division line management reviews the status of all open ESHTRK findings.

More details of independent assessments are described in the TD Self-Assessment Program (SAP). Refer to Appendix A for the most current location of the Self-Assessment Program.

Section 1:

Technical Division Organization Chart

http://www-td.fnal.gov/ ("Tech Division Info" tab)

Fermilab Policy Manual

http://www.fnal.gov/directorate/documents.html ("Fermilab Director's Policy Manual")

Fermilab ES&H Manual

http://www-esh.fnal.gov/home/esh_home_page.html ("Manuals and Procedures")

Appendix I of the DOE/Fermilab Prime Contract

Available in hard-copy from the Directorate (bobgrant@fnal.gov).

TD Policies and Procedures Manual

Hard-copy distributions in the headquarters library and the Senior Safety Officer. Documents are also being migrated to the TD home page http://www-td.fnal.gov/ - click on the "Tech Division Info" tab.

Section 2:

Fermilab ES&H Manual

http://www-esh.fnal.gov/home/esh_home_page.html ("Manuals and Procedures")

Performance Review

http://fnalpubs.fnal.gov/policyguide/art01set.html (article 25)

See also http://fnalpubs.fnal.gov/lssection/2000review.html, and replace the year with the current year.

TRAIN database

http://www-esh.fnal.gov/home/esh_home_page.html ("Training and TRAIN")

Grassroots Committee Guidance Document

Available in hard copy from division headquarters.

Section 3:

Technical Division Self-Assessment Program TD-2020

Hard-copy distribution in TD Headquarters. Electronic version maintained in the "OnBase" document management system under "TD Quality Assurance", URL http://td-docs.fnal.gov/webdms/login.asp.

Performance Review

http://fnalpubs.fnal.gov/policyguide/art01set.html (article 25)

See also http://fnalpubs.fnal.gov/lssection/2000review.html, and replace the year with the current year.

Section 4:

Fermilab Records Management Program

http://www-bss.fnal.gov/RecordsManagement/handbook.html

DOE Records Management

http://www-it.hr.doe.gov/records/

General Records Schedule 20 - Electronic Records

http://andor.nara.gov/grs/grs20.htm

36 CFR Part 1234 - NARA Electronic Records Management

http://www.access.gpo.gov/nara/cfr/cfr-table-search.html (there are various search methods, choose one that suits your needs)

Technical Division records management tools:

OnBase® document/records management system

http://tdserver1.fnal.gov/proeng/

TD Technical Notes

Used to document, publish and organize results of work activities. Speak with Sharon Spatafora about the details of this system. Documents can be downloaded from http://tdserver1.fnal.gov/tdlibry/TD-Notes/.

Fermilab Drawing Control System (DCS)

http://www-cad.fnal.gov/groupinfo/dcs/dcsinformation.html

Section 5:

Fermilab ES&H Manual

http://www-esh.fnal.gov/home/esh_home_page.html ("Manuals and Procedures")

Device Data Management System TD-2030

Hard-copy distribution in TD Headquarters. Electronic version maintained in the "OnBase" document management system under "TD Quality Assurance", URL http://td-docs.fnal.gov/webdms/login.asp.

Section 6:

TD Technical Notes

All notes available from the TD network at \\tdserver1\project\Tdlibry\TD-Notes (web address http://tdserver1.fnal.gov/tdlibry/TD-Notes/). Some notes available from the web in a searchable database at http://tdpc84.fnal.gov/cgi-bin/docLib-prd/document.pl.

FESHM chapters (all found in the Fermilab ES&H Manual):

2010 - Planning and Review of Accelerator Facilities and Their Operations
5021 - Overhead Cranes, Hoists and Rigging
5031 series - Pressure Vessels and Piping
5032 series - Cryogenic Systems
5033 - Vacuum Vessel Safety
5034 - Pressure Vessel Testing
5035 - Mechanical Refrigeration Systems

National Codes (ASME codes available in hard-copy in EF Design & Drafting group and the laboratory library):

ASME Boiler and Pressure Vessel Code Section VIII
ANSI/ASME Y14.5M - Dimensioning and Tolerancing
ASME B30.20 - Below-the-Hook Lifting Devices
ASME B31.1-9 - Piping
National Electrical Codes Handbook (available in hard-copy in DT Instrumentation & Controls group and from the laboratory library)
ANSI/ISA-S5.1 - Instrumentation Symbols and Identification (available in hard-copy in DT Instrumentation & Controls group)

Procedure for the processing of ERs and ECOs - Specification #5500-ES-360000

Available in hard-copy from the Engineering and Fabrication department (the scope of this procedure is devices designed by EF).

Section 7:

Fermilab Procurement Manual

http://www-bss.fnal.gov/Procurement/index.html

Fermilab ES&H Manual

http://www-esh.fnal.gov/home/esh_home_page.html ("Manuals and Procedures")

TD Policies and Procedures Manual

Hard-copy distributions in the Headquarters library and the Senior Safety Officer.

DOE Suspect & Counterfeit Items

http://twilight.saic.com/qawg/ ("Alerts and Advisories")

Section 8:

National Institute of Standards and Technology (NIST)

http://www.nist.gov/

Section 9:

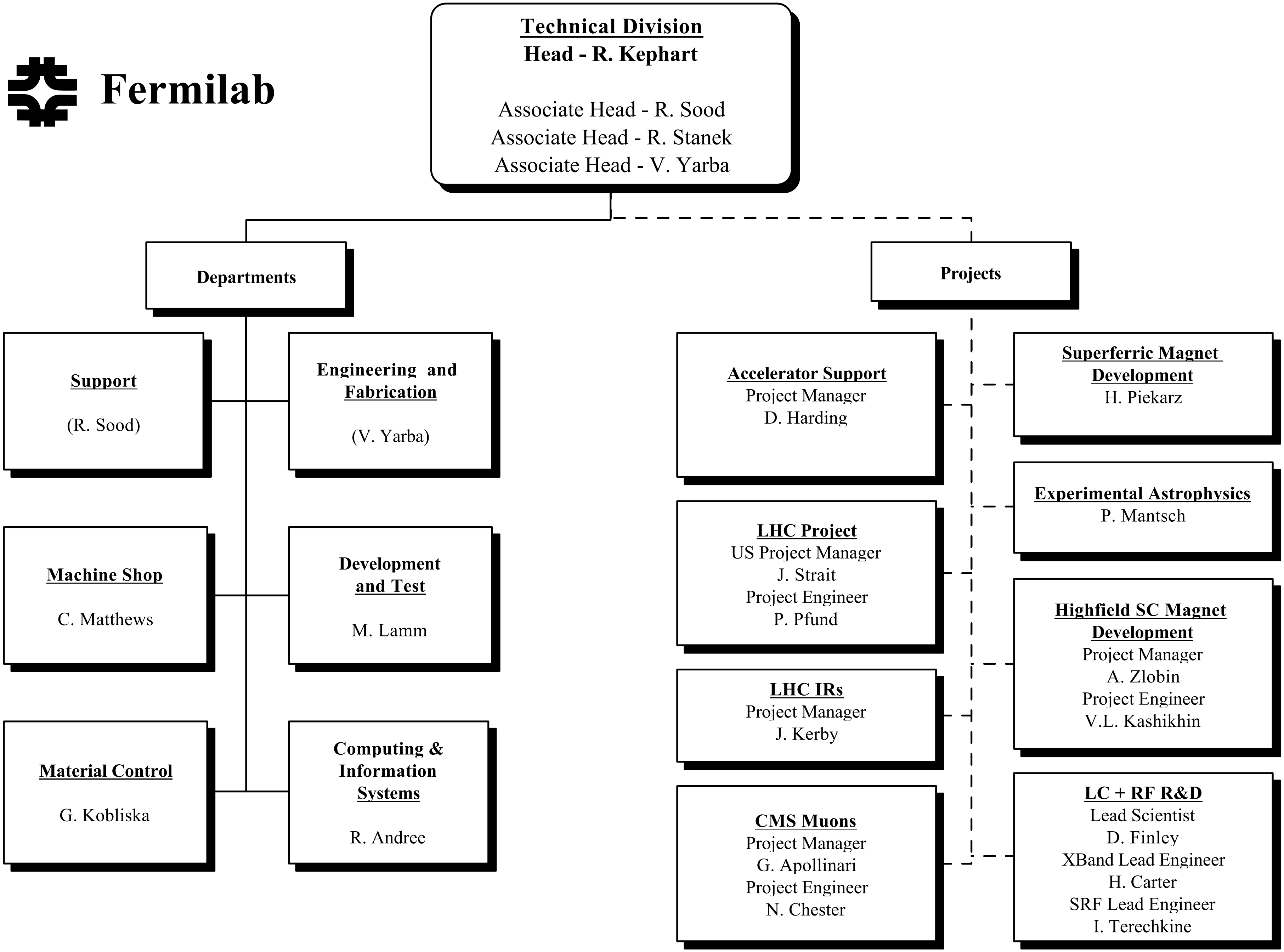
Technical Division Self-Assessment Program TD-2020

Hard-copy distribution in TD Headquarters. Electronic version maintained in the "OnBase" document management system under "TD Quality Assurance",
URL http://td-docs.fnal.gov/webdms/login.asp.

ESHTRK

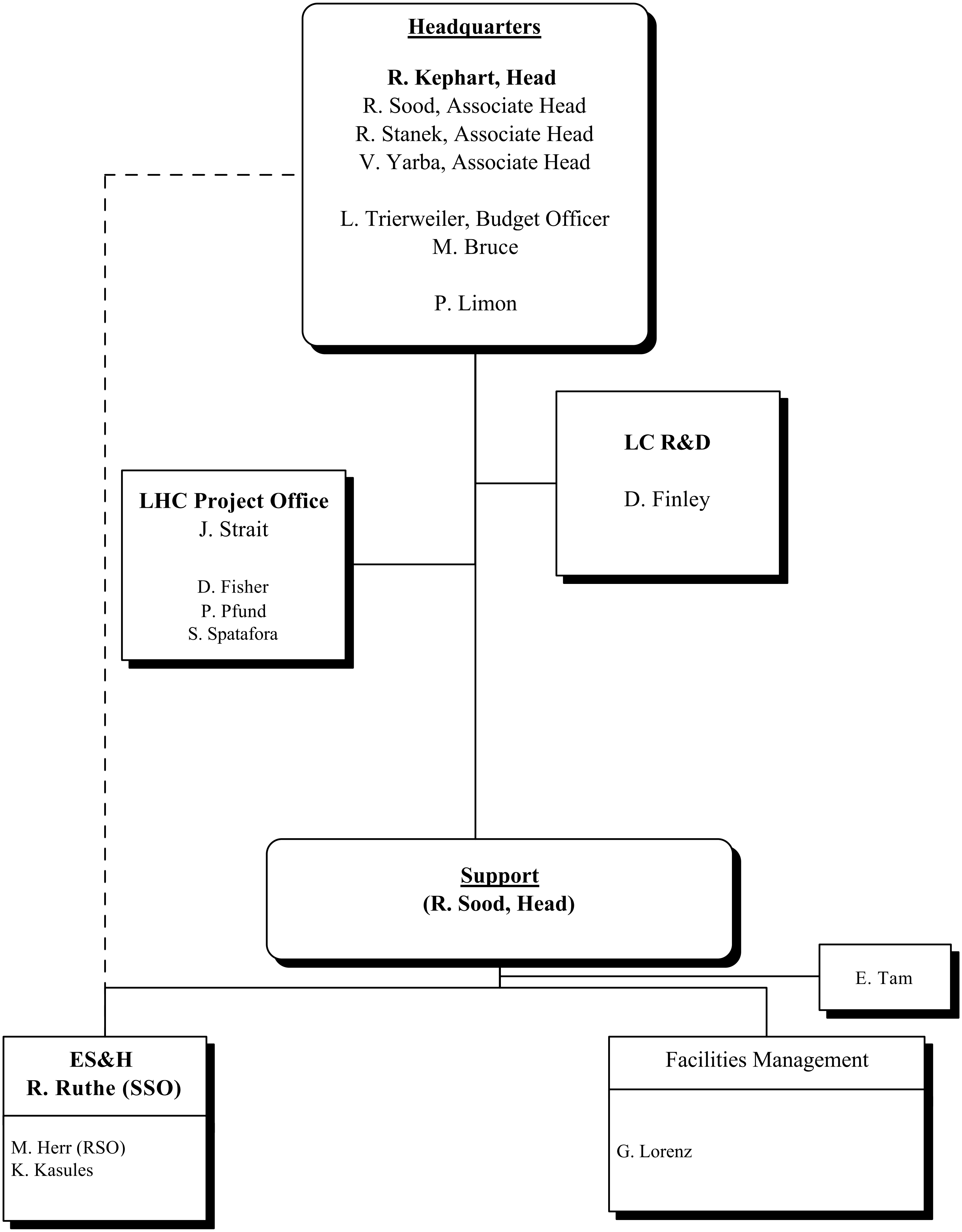
http://www-esh.fnal.gov/home/esh_home_page.html ("Assessments and ESHTRK")

Fermilab



Approved - R. Kephart
August 1, 2002

Solid line indicates administrative responsibility
Dashed line indicates functional responsibility


Headquarters
R. Kephart, Head
R. Sood, Associate Head
R. Stanek, Associate Head
V. Yarba, Associate Head
L. Trierweiler, Budget Officer
M. Bruce
P. Limon
LHC Project Office
J. Strait
D. Fisher
P. Pfund
S. Spatafora
LC R&D
D. Finley
Support
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E. Tam
ES&H
R. Ruthe (SSO)
M. Herr (RSO)
K. Kasules
Facilities Management
G. Lorenz

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(J. Carson, Deputy)
G. Sliwicki, Building Manager

RF Technology Development
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T. Arkan
T. Battista (S)
M. Battistoni
C. Boffo
E. Borissov
I. Gonin (G)
A. Kazakov (S)
T.Khabiboulline(G)
G. Linder (S)
T. Nicol
(T. Page)
G. Romanov (G)
B. Smith
N. Solyak

Highfield SC Magnet
V. Kashikhin
N. Andreev
S. Bhashyam
D. Chichili
(L. Elementi)
I. Novitski
S. Yadav

LHC IRs
J. Kerby
R. Bossert
(T.Nicol)
A. Nobrega
T. Page

CMS Muons/ CKM
G. Apollinari
V.Barashko(G)
N. Chester
O. Prokofiev

Superferric Magnet
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A. Oleck

Material Development Lab
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D. Burk
S. Larson (S)

Engineering Lab
(R. Bossert)
T. VanRaes
T. Wokas

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J. Brandt
M. Battista (PT)
P. Belko
H. Brown
G. Davis
K. Ewald
J. Jablonski
A. Knauf
L. Litvinenko
S. Meredith
D. Pasholk
J. Sachtschale
A. Simmons
G. Zielbauer (PT)

Fabrication
J. Carson

Tooling
L. Elementi
D. Assell
D. Connolly
W. Robatzek
R. Smith
S. Strysik
O. Webb (S)

Assembly
D. Smith
H. Brooks
P. Gallo
R. Hill (T)
J. Jones
W. Ostrom (T)
M. Phelps
C. Pribyl (T)
I. Samayavong
P. Sanchez
S. Sanchez
J. Schmitt (T)

CMS
G. A. Smith
M. Chlebek (T)
K. Dees (T)
D. Eddy (T)
H. Szuba-Jensen(T)
W.Vanderheyden(S)
J.Wittenkeller

Run II and Accelerator Support
(R. Bossert)
D. Harding
(J. Brandt)
(J. Carson)
R. Hanft (G)
A. Makarov
D. Mitchell
W. Robotham
D. Sorensen

Process Engineering
J. Blowers
M. Cullen
T. Gardner
D. Gaw
R. Jensen
Y. Klukhina (S)
J. Szal

R&D Support
(R. Bossert)

J. Alvarez
E. Andree(S)
D. Bice
R. Evans (T)
O. Frianeza (T)
S. Gould
A. Levy (T) (L)
P. Mayer (T)
D. Nurczyk
J. Rife
E. Ruiz
W. Schewe (T)
E. Strysik (T)
G. Whitson

Administrative Support
K. Swanson

E. Noyola
F. Peterson
K. Poloubotko (S)

Machine Shop
C. Matthews, Superintendent
J. Peterson, Assistant Superintendent

S. Larson

L. Ramirez, Supervisor
Village Machine Shop

M. Berens
G. Bulat
P. Cowan, Jr.
E. Hagler
L. Jackson
R. Johanek
A. Kandziorski
W. Koch
A. Laroche
O. Lira
R. Mabe-Wortman
G. Markiewicz
J. Mueller
H. Parkhurst
C. Penson
K. Sra
R. Wagner

Cut Shop

G. Green

B. Stroud
Supervisor - Wilson Hall Machine Shop

H. Blair
M. Eriks
A. Haugen
P. Hughes
T. Kelly
J. Nowak
J. Wilson

Tech Shop Machinists

H. Cunningham
D. Fisher
J. Henry
R. Leber
W. Medley

R. Hiller
Supervisor
Weld Shops

M. Cooper
C. Dyrda
W. Gatfield
L. Harbacek
J. O'Neill
M. Reynolds
J. Roberts
C. Sood
D. Watkins
R. Williams

(J. Peterson)
Supervisor - Machine Repair

T. Bucio
T. McGowan
W. Tollefson

Tech Shop Machinists

M. Kerwin
J. Reed
S. Walters
E. Weiten

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H. Glass, Deputy

K. Ohman

Test Operations
M. Tartaglia

Cryogenic Operations and Engineering
C. Sylvester

C. Hess
R. Rabehl
C. Reid

Mechanical Techs
A. Bianchi

G. Kirschbaum
D. Massengill
W. Mumper
A. Rusy
M. Thompson
D. Validis
R. Ward
F. Wilson

Instrumentation and Controls
R. Carcagno

Tech Support
Y. Pischalnikov

S. Helis
D. Krause
F. Lewis

Projects
D. Orris

J. Garvey
A. Makulski
R. Nehring

Superconducting Magnets
A. Zlobin

G. Ambrosio
E. Barzi
L. Del Frate (T)
L. Imbasciati (T)
V. Kashikhin
B. Kaspar (S)
E. Marscin (S)
R. Yamada

Systems Development and Support
J. Nogiec

F. Burzynski (S)
E. Desavouret
K. Trombly-Freytag (PT)
P. Hall (PT)
S. Kotelnikov
A. Malu (S)
D. Walbridge

Measurement and Analysis
(H. Glass)

V. Maroussov (S)
J. DiMarco
P. Schlabach
G. Velev

Accelerator and Detector Projects

P. Bauer
S. Feher
Y. Huang
T. Peterson
J. Tompkins

Experimental Astrophysics
P. Mantsch

R. Andrews
M. Kaducak
P. Mazur
S. McCook

Material Control
G. Kobliska, Head
(J. Zweibohmer, Deputy)

A. Tanjuaquio

Acquisition
J. Zweibohmer

L. Alsip
S. Hickey (L)
P. Olderr
M. Schmidt
M. Steinke

IB4 Operations
L. Peters

Quality Control
Ted Beale

S. Ghanta
F. Juravic
S. Merkler
R. Riley
T. VanRaes

Magnet & Component Storage
(L. Peters)

C. Besch
W. Kelley
P. Schmidt
G. VeZain

Computing & Information Systems
R. Andree, Head

G. Carbo-Finstrom
C. Diebold (PT)
M. Dietrich (S)
J. Hammer
J. Konc
J. Morris
E. Peterson (S)
P. Wang

Legend

(C)	Coop Student
(G)	Guest
(L)	On Leave
**	On Loan
(PT)	Part-Time Employee
(RSO)	Radiation Safety Officer
(SSO)	Senior Safety Officer
(S)	Summer
(T)	Temporary or Term

Fermi National Accelerator Laboratory

United States Compact Muon Solenoid Collaboration

US-CMS CATHODE STRIP CHAMBER QUALITY ASSURANCE PLAN
Version 1

Approved, CMS-CSC Project FNAL Site Manager	8/21/00 Date
Approved, CMS-CSC Project Engineer	8/21/00 Date
Approved, Technical Division Head	9/14/00 Date
Approved, Technical Division Quality Assurance Officer	8/28/00 Date

Purpose

The purpose of this Quality Assurance Plan is to describe Fermilab's effort on the Cathode Strip Chamber portion of the Compact Muon Solenoid Project. This document is formatted following the criteria defined in DOE O 414.1A Quality Assurance, and the Technical Division Quality Management Program, TD-1.

Each section of this document begins with a policy statement for the Technical Division. The CMS-CSC Project adheres to the TD policies, unless otherwise stated.

Scope

The description and requirements in this plan are generally applicable to all activities included in the CSC portion of the CMS Project. All the detailed requirements that are specified in the TD Quality Management Program are not repeated here. The CMS Project Management has assigned the responsibility for execution of the CSC Project to the Technical Division.

1.0 Program

1.1 Policy

The policy of the Technical Division is to develop, document, and maintain it's quality management program, so that the Division may satisfy the needs of its customers.

1.2 Mission

The mission of *Fermi National Accelerator Laboratory* is:

"Advancing the understanding of the fundamental nature of matter and energy by providing leadership and resources for qualified researchers to conduct basic research at the frontiers of high energy physics and related disciplines."

The mission of the *Technical Division* is:

"The development, design, fabrication or procurement, and testing of accelerator and detector components."

The mission of the *Cathode Strip Chamber Project* at Fermilab is to:

1) Design, build, and test Cathode Strip Chambers;
2) Prepare component kits for assembly by other collaborating institutions;
3) Deliver compliant chambers to US Fast Sites for electronics integration.

1.3 Objectives, Goals and Functional Responsibilities

[1] <u>To design and fabricate required detectors for the CERN LHC</u>.

The Engineering & Fabrication Department is responsible for the design of the manufacturing tooling and the chambers that are required in this project.

[2] <u>To procure, inspect, inventory, and deliver the various materials needed for this project</u>.

The Material Control Department is responsible for these functions. The Engineering & Fabrication Department interfaces with the Material Control Department and other groups, as required, to assist the procurement section of Fermilab in procuring the needed material.

Inspection of the procured materials will be required. See section 8.0 for details. The storage and inventory of the components for the chambers may be required in some cases.

[3] To test the chambers.

All the detectors that are to be fabricated will be tested for functionality. See section 8.0 for specifics on Inspection and Acceptance Testing.

[4] To oversee the scheduling of milestones, to budget and control cost, and to report to the Level 3 manager timely status reports, as required by the project office.

These functions are assigned to the Fermilab CSC Site Manager & CSC Project Engineer, who are assisted by their staff and other project personnel. This includes reporting on the resource requirements and status of the project to the Technical Division Head.

[5] To create and maintain a Quality Assurance program.

Although quality is the responsibility of every Fermilab employee, the task of creating and maintaining the QA program is assigned to the Quality Assurance Officer.

[6] To perform the required material development for this project.

This task has been assigned to the Material Development Laboratory in the Engineering & Fabrication Department, on an as-needed basis.

[7] To provide a qualified staff for the performance of this project and to provide the needed laboratory work space.

This function is the responsibility of the Technical Division Head, acting on input supplied by the CSC Site Manager & CSC Project Engineer.

1.4 Organization Structure

Attached is the organizational chart for the CMS-CSC Project (see Attachment I). The organizational structure/responsibilities for collaborative groups, i.e. Universities of Florida and Wisconsin, are defined using Memorandums of Understanding (MoU's) and Statements of Work (SoW's). The signed approved original MoU's and SoW's are maintained by the US-CMS project office.

Although the CMS Project is conducted as a collaborative team effort, the CMS-CSC Project Manager has ultimate responsibility for the completion of the project.

Clear and frequent communication is always encouraged among the project participants, and is critical to the success of the CMS-CSC Project. Informal communication via notes, phone calls, electronic mail, and informal discussions are exchanged frequently between the participants. This information flow encourages the exploration of the viability of plans and solutions, and allows for the resolution of any issues that arise. Although it is not a project requirement, the distribution of copies of informal correspondence to all participants is desirable to keep everyone apprised of the most current information available.

Management's systems for performing and assessing adequacy of work on the CMS-CSC's, including activities that relate to planning, scheduling, and cost control are described in detail in the following documents:

1. CMS Project Management Plan
2. Technical Division Quality Management Program
3. Technical Division Self-Assessment Program

1.5 Roles, Responsibility, and Authority

1.5.1 Project Site Manager, CSC Project

- Project Site Manager is responsible to the CMS Level 3 Manager for delivering acceptable chambers and chamber kits.
  - ♦ Manage the third level of the WBS for detectors with accepted Fermilab practices.
  - ♦ Record control account and schedule status on a timely basis.

- Represent the detector project to the collaborators and L3 and above, providing them, as required and funded, with resources, e.g. staffing, space, machine shop priority, et cetera.
- Ensure that requirements and specifications are provided to appropriate Technical Division groups on a timely basis.
- Implement the QA Plan.
- Assure the quality of the delivered products.

1.5.2 Engineering and Fabrication Department Head

Responsible for providing support, oversight, direction, and feedback to project managers.

1.5.3 Quality Assurance Officer

- Responsible for the creation and maintenance of the Quality Assurance Plan.
- Responsible for providing support to the CMS-CSC Project staff throughout the project.

1.5.4 Technical Division Head

Provide support to project personnel, and aid in solving problems that cannot be solved on a lower level.

1.6 Organizational Interface

1.6.1 CMS Project Office/TD-HQ

- Communicate project status when changes occur and periodic, e.g. monthly, reports.
- Determine staffing requirements for CMS-CSC Project within TD
- Resolve resource allocation issues, e.g. draftsman assignments, machine shop priorities, and space allocation.

1.6.2 CMS Project Office/Fermilab Business Office

- Procurement representative will attend weekly CMC-CSC design/fabrication meeting with CMS Project Managers and TD

1.6.3 CMS Project Office/Level II and Level III Managers

- Develop requirements and specifications to fulfill the goals of the CMS Project. The CMS Project Manager will approve requirements and specifications. Attachment III defines this interface.
- Conduct weekly meetings with Fermilab Business Manager and CMS Project Manager to discuss issues and procurement status

2.0 Personnel Training and Qualifications

2.1 Policy

The policy of the Technical Division is to hire and maintain personnel who posses the appropriate level of skill, experience, and academic qualifications to support the achievement of the CMC-CSC's mission.

2.2 Training

In-house training is provided to ensure that an appropriate level of skills, knowledge, expertise, and experience are available to accomplish the stated mission and objectives.

Training may come from several sources such as mentoring provided by physicists, engineers, supervisors, lead personnel, consulting firms, technical operating manuals, and other sources. Job-related training records of all assigned personnel, for work related to the CMS Project, are maintained by the respective supporting organization.

2.3 Qualifications

Qualifications for personnel working on the CMS are based upon the responsibilities of the position and project needs, which define the level of education, extent of work experience, knowledge and specific skill requirements.

3.0 Quality Improvement

3.1 Policy

The policy of the Technical Division is to continuously improve in all areas and activities for which it is responsible.

3.2 Quality Implementation

- This document is the guide for the development and implementation of quality assurance for the CMS-CSC Project, and is used to support the achievement of the stated mission and performance objectives. This document further ensures that appropriate procedures are in place that describes the extent and method of how the quality requirements will be implemented.
- It is the intent of the CMS Project Manager that all activities be performed at a level of quality appropriate to achieving the scientific, technical, operational, and administrative objectives.

3.3 Quality Responsibilities

- All personnel performing a function at Fermilab are responsible for quality and are encouraged to promptly report conditions adverse to quality such as deviations, deficiencies, failures, defective items or processes, and nonconformances, to the appropriate level of management.
- Personnel closest to the daily operation or activity are in the best position to understand and report nonconforming conditions, and are encouraged to participate in quality improvements to meet the needs of the customer and to achieve the objectives of the project mission.
- Strong emphasis is placed on line supervision leadership, accountability, and the implementation of quality tools at the line level.
- Management is responsible for providing the necessary resources for conducting root cause analysis and for implementing corrective and preventive actions.

3.4 Performance Cause Analysis

3.4.1 Supplier Performance

Supplier performance problems are identified and reported through the mechanism of Quality Control Reports (QCRs), generated by the Material Control Department's Incoming Inspection group for items such as incoming parts, assemblies, and supplied purchased hardware. These reports are reviewed and approved by the responsible authority/physicist (or designee) of the area or activity in which they will be used and by the

Material Control Department Head (or designee). The review will cover problems that may have significant programmatic effect or risk factors affecting cost, schedule, ES&H (personnel safety), or configuration. The appropriate disposition is given, i.e. scrap, return to vendor for replacement, rework at vendor, rework in house, or use as is. These reports are reviewed for supplier performance problems or trends and are used as a basis for cause analysis and necessary corrective action.

3.4.2 Work Process Performance

Discrepancy Reports have been developed and implemented to document problems during assembly or fabrication such as deviations, deficiencies, failures, defective items/materials or processes, malfunctions, trends, and/or non-conforming conditions.

The responsible authority of the activity or area of occurrence reviews these discrepancy reports for technical evaluation, cause determination, disposition, and corrective/preventive action recommendation.

Process Engineering performs a review of these reports to ensure that reports are completed properly and that preventive action is adequate; the QA Manager may also recommend follow up corrective/preventive action or verification/validation as required. These discrepancy reports are used as a basis for trends, cause analysis, and/or lessons learned.

4.0 Documents and Records

4.1 Policy

The policy of the Technical Division is to maintain adequate documentation and records to ensure quality requirements are met, while recognizing the objective of minimizing paperwork and cost.

4.2 Controlled Documents

4.2.1 Controlled documents are created, implemented, and maintained at a level commensurate with the level of work being performed and as dictated by sound quality assurance practices.

4.2.2 The TD maintains the following documents under document control:

- CMS-CSC Quality Assurance Plan
- Released Engineering Drawings and Technical Specifications
- Quality Control Travelers

4.3 Documents and Records Responsibilities

4.3.1 Quality Assurance is responsible for the release, revision, and distribution of the CSC QA Plan.

4.3.2 The Engineering and Fabrication department is responsible for the control of documents and data pertaining to engineering specifications, engineering procedures, drawings, and Quality Control Travelers; and for the control of documents and data regarding CSC testing.

4.3.3 The Material Control Department is responsible for the control of documents and data associated with the procurement of materials for the assembly of the chambers.

4.4 Documents and Records Procedures

4.4.1 All controlled documents:

1. Are reviewed and approved by authorized personnel prior to being issued/revised.
2. Have a revision history maintained.
3. Are available to all personnel who need access.

4.4.2 All records are maintained in accordance with the Fermilab Records Management Program (based on DOE Order 1324.5B).

5.0 Work Processes

5.1 Policy

The Technical Division's policy is that work processes be well thought out, appropriately documented and reviewed, and that they be carried out by competent and effective workers.

5.2 Responsibility

5.2.1 The CSC Project Site Manager's responsibility, as defined in 1.5.1, includes administering, planning, organizing, and controlling the CSC Project to meet the project technical, cost, and schedule objectives. In particular, the CSC Project Site Manager strives to encourage effective human resource management with the goals of hiring and maintaining an efficient and effective work force.

5.2.2 The individual CSC worker is the first line in ensuring quality. They are responsible for following the procedures defining the assembly and quality control checks in the fabrication of the chambers, i.e. Quality Control Travelers. They also have the authority to report any possible nonconformities to management, and may participate in cause analysis and continuous improvement.

5.2.3 The Department Heads are responsible for ensuring that people who assigned to tasks have the appropriate academic qualifications, professional certifications, or skills and experience to carry out the work successfully.

5.2.4 The CSC Project Site Manage, the CSC Project Engineer, and other project staff, as appropriate, are responsible for planning, authorizing, and specifying (to an appropriate level of detail), the conditions under which work is to be performed. This includes the calibration of measuring and test equipment (see section 8). This group also specifies which work is sufficiently complex or involves sufficient hazard to be performed to written procedures.

5.2.5 The Engineering & Fabrication Department is responsible for the inspection and test status, identification and traceability, and for the creation and maintenance of the QCTs for the chambers (see 5.4).

5.2.6 The Material Control and Engineering & Fabrication Departments share responsibility for the handling, storage, and preservation of chamber components and completed chambers.

5.3 Production Process Control

Attachment IV defines the workflow for the fabrication of the chambers.

The EF Department Head, in conjunction with the CSC Site Manager and CSC Project Engineer, is responsible for ensuring that production processes are carried out under controlled conditions. When planning the production processes, the following are considered:

- All applicable government safety and environmental regulations
- Use of QCTs (or other such work instructions) to document the methods of production. These should be used when the absence of such procedures could be adverse to quality.
- Defining suitable equipment and work environment to ensure quality.
- Defining suitable maintenance of equipment to ensure continuing process capability.
- Defining the criteria for workmanship in the clearest practical manner. Examples of this are work instructions that document tolerances for process parameters, samples or pictures of "quality" product, samples or pictures of poor quality or failure modes to look for.
- Level of education and experience required for production operators.
- Training needs for production operators.

5.4 Quality Control Travelers (QCT's)

A system of Quality Control Travelers is used to define the sequence of fabrication, inspection, and testing to be performed for the chambers. Witness/Hold points are designated in QCT's at a turning point or important juncture of the fabrication. QCT's provide for sign-off by qualified personnel and are dated at the completion of each fabrication sequence, welding operation, and inspection/test procedure by designated inspection/test personnel, fabrication personnel, or welding personnel to assure completion, date completed, and sequence of required operations.

Training of project personnel in the usage of QCT's is accomplished with a "walk-thru". The "walk-thru" training is conducted and documented by Process Engineering. The initial training simulates an actual operation (e.g. panel winding) using the QCT in a step by step sequence. The goal of the initial training is to familiarize all personnel with the proper usage of QCT's in general, as well as to help everyone understand how the particular operation is designed to be completed.

Subsequent training of QCT revisions may be accomplished by routing the revised QCT to the appropriate personnel for signature, signifying that the revised QCT has been read and understood.

6.0 Design

6.1 Policy

The policy of the Technical Division is to ensure that designs perform as intended. This is accomplished by incorporating sound engineering/scientific principles and appropriate technical standards into designs.

6.2 Requirements

The CSC Project Site Manager and CSC Project Engineer implement the design policy. The CMS Title I Design Report (the CMS design handbook) has been independently reviewed in order to assure compliance with this policy.

The chambers fabricated at Fermilab must fulfill the requirements defined in the CMS design handbook. Any changes to the chamber design, as defined in the handbook, must be reviewed and approved by the appropriate level of management (see section 8 of the US-CMS Project Management Plan, Project Management System).

6.3 Drawings and Specifications

Formal drawings are generated and stored through the Engineering and Fabrication Department, and these drawings are reviewed and approved by the appropriate level of management.

6.4 Design Reviews

At appropriate stages of design, formal documented reviews of the design results are planned and conducted. Participants at each review include representatives of all functions concerned with the design stage being reviewed, as well as other qualified personnel (this may include ES&H). These reviews are completed in order to:

1) Identify potential problem areas or inadequacies;
2) Assess issues affecting safety and quality;
3) Initiate corrective/preventive actions;
4) Ensure that the design minimizes ES&H impact and satisfies all FNAL ES&H policies and external codes.

Results from the reviews are used as a basis for verifying that design stage outputs meet the design stage input requirements.

6.5 Design Validation

Designs are validated through the testing of the complete prototype system (or subsystem) during and after assembly, against the performance specifications. This testing includes the utilization of a cosmic ray test stand.

6.6 Design Changes

Appropriate design controls are incorporated into the CSC project by using configuration management. The change management mechanism, defined in section 8 of the US-CMS Project Management Plan, is used by the CSC project.

Proposed changes that affect the life, performance, reliability, or integration with other sub-systems, are reviewed and dispositioned by the Configuration Control Group (L2 and L3 managers). In order for the new design to be approved, the initiator must convincingly demonstrate that either the old design is not adequate, or that the new design has superior performance and/or cost advantage(s) over the old.

7.0 Procurement

7.1 Policy

The Technical Division policy is to ensure that items and services provided by suppliers meets the requirements and expectations of the end-users.

7.2 Requirements

The Fermilab contract with the DOE specifies a variety of management controls to be applied to procurements and sub-contracts through the applicable DOE orders, DOE Acquisition Regulations (DEAR), and Federal Acquisition Regulations (FAR). To this end, all procurement activities are performed in accordance with the *Fermilab Procurement Policy and Procedures Manual* and the *Fermilab ES&H Manual*.

Only approved material will be used in the production of the CSC's. The Material Control Department has the responsibility of procurement for the Technical Division and the CMS-CSC project.

7.3 Supplier Qualification and Selection

Suppliers are evaluated and selected on the basis of their ability to meet subcontract requirements. These requirements are appropriately defined in approved Engineering Drawings and Technical Specifications, and include specific quality assurance requirements.

Topics that are usually evaluated include, but are not limited to:

- Quality assurance program
- Ability to meet all requirements
- Cost
- Financial solvency
- Work history

7.4 Budget Authority

The Division Head, in conjunction with the budget defined by the CMS Project Office, assigns expenditure level to individuals responsible for a specific work package. Procurement of items and services that are above the stated expenditure level require Division Head review and approval. Attachment II defines proposed expenditure levels.

8.0 Inspection and Acceptance Testing

8.1 Policy

The Technical Division policy is to ensure that all items, components, and services meet the specified requirements. This is verified through the use of inspection and acceptance testing.

8.2 Requirements

As defined in section 5.2.4, the CSC Project Site Manager and the CSC Project Engineer define the types of work that require formal inspections and acceptance testing. When an inspection or acceptance test is performed, the characteristics and processes to be inspected or tested, the inspection techniques to be used, the hold points, and the acceptance criteria are defined, as appropriate.

Inspection and acceptance testing (to include receiving, in-process, and final) are performed in accordance with proper training and/or written procedures.

The Material Control Department works with the CSC Project Engineer to define and document receiving acceptance testing for incoming materials. The Quality Control Traveler defines the testing during the assembly of the chambers (in-process). The final inspection will include a sample of chambers undergoing testing in a cosmic ray test stand.

Properly calibrated (traceable to NIST) and maintained measuring and test equipment are used for all testing.

8.3 Records

To allow for traceability, adequate records are maintained for all inspections and tests. These records include observations made, inspection/test results, identification of the personnel conducting the inspection/test, date, and time.

9.0 Management Assessment

9.1 Policy

The Technical Division's policy is to regular assess the Division's effectiveness in meeting it's objectives, goals, and compliance to orders and regulations. This is accomplished using the Technical Division Self-Assessment Program.

9.2 Requirements

Technical Division management will evaluate the TD's role in the CMS Project, in order to ensure the Division's continuing suitability in fulfilling the requirements of the CMS Project.

9.3 Methods

Details from the TD Self-Assessment Program are not repeated here. Assessments are made using formal and informal meetings and other communications. Examples are:

- Division Head meeting with Department Heads or other supervisory staff
- Department Heads meeting with line supervisors and other lead personnel
- Suggestions and recommendations from project personnel
- Design Reviews & Production Readiness Reviews
- Independent assessments (see Section 10.0)

9.4 Feedback

Information gathered during management assessments is used to provide feedback to the CMS Project personnel. This information will allow project personnel to make improvements and any necessary corrective/preventive actions, so that the goals of the CMS Project may be met.

10.0 Independent Assessment

10.1 Policy

The policy of the Technical Division is to utilize independent, i.e. third party, audits to ensure the Division's effectiveness in meeting it's objectives, goals, and compliance to orders and regulations.

10.2 Requirements

The CMS Project will be audited and evaluated by a third party, as needed. The audit(s) are used to insure that the quality management system is effective in achieving the stated mission.

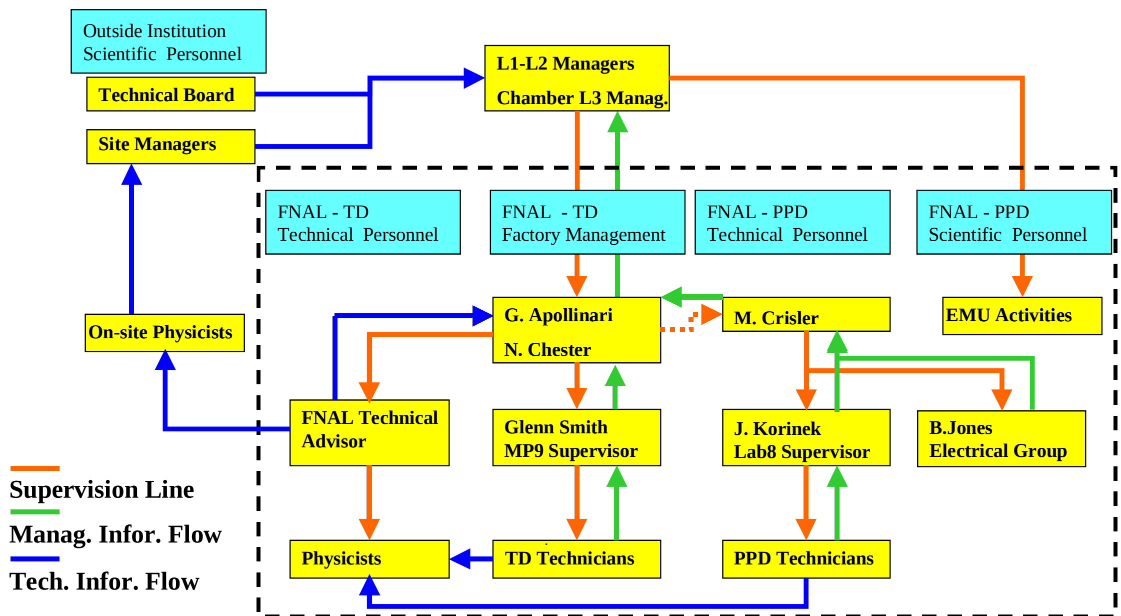
In order to evaluate the quality management system on a regular basis, an audit plan will be created and implemented by management. When performing the audits competent technical personnel will be utilized as auditors. These auditors are independent of the specific activities or areas being audited. Management, having responsibility in the area audited, and to assure corrective action and involvement of personnel of the specific areas of the audit, will review documented audit results.

10.3 Responsibilities

The Quality Assurance Officer is responsible for coordinating independent assessments and, as team leader and spokesperson, will provide leadership, guidance, audit procedures, and audit plans.

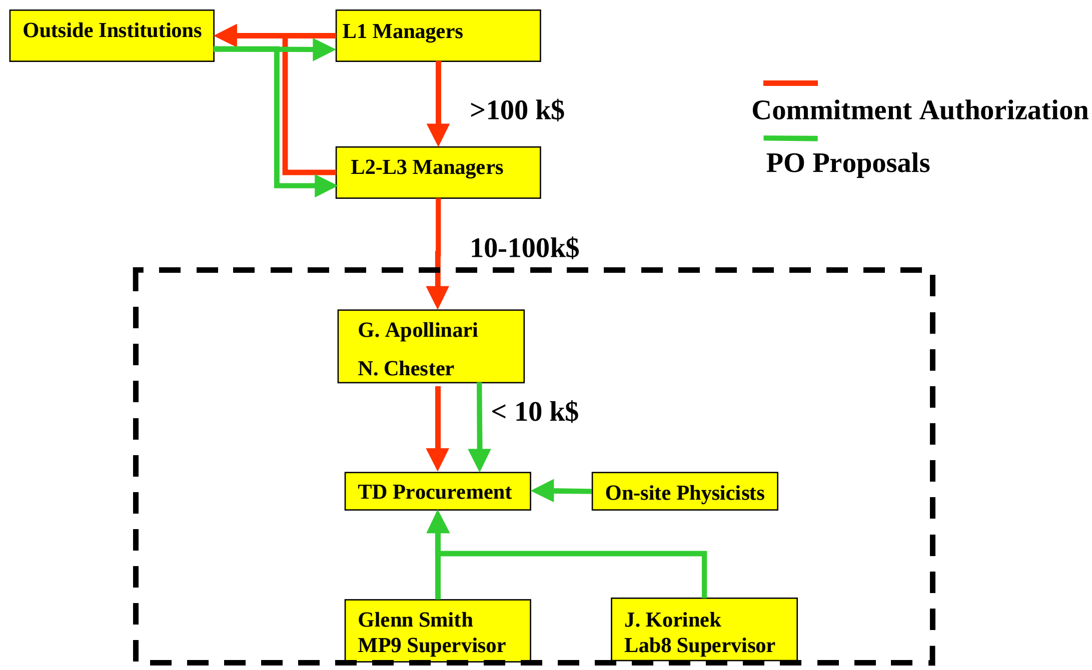
ATTACHMENT I

EMU Chambers Production Supervision Lines @ FNAL



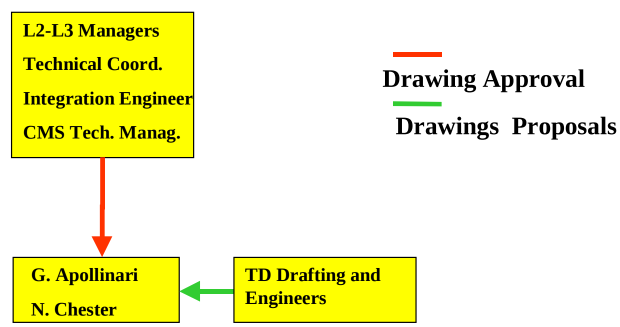
ATTACHMENT II

EMU Chambers Production Commitment Authorization PO Proposal



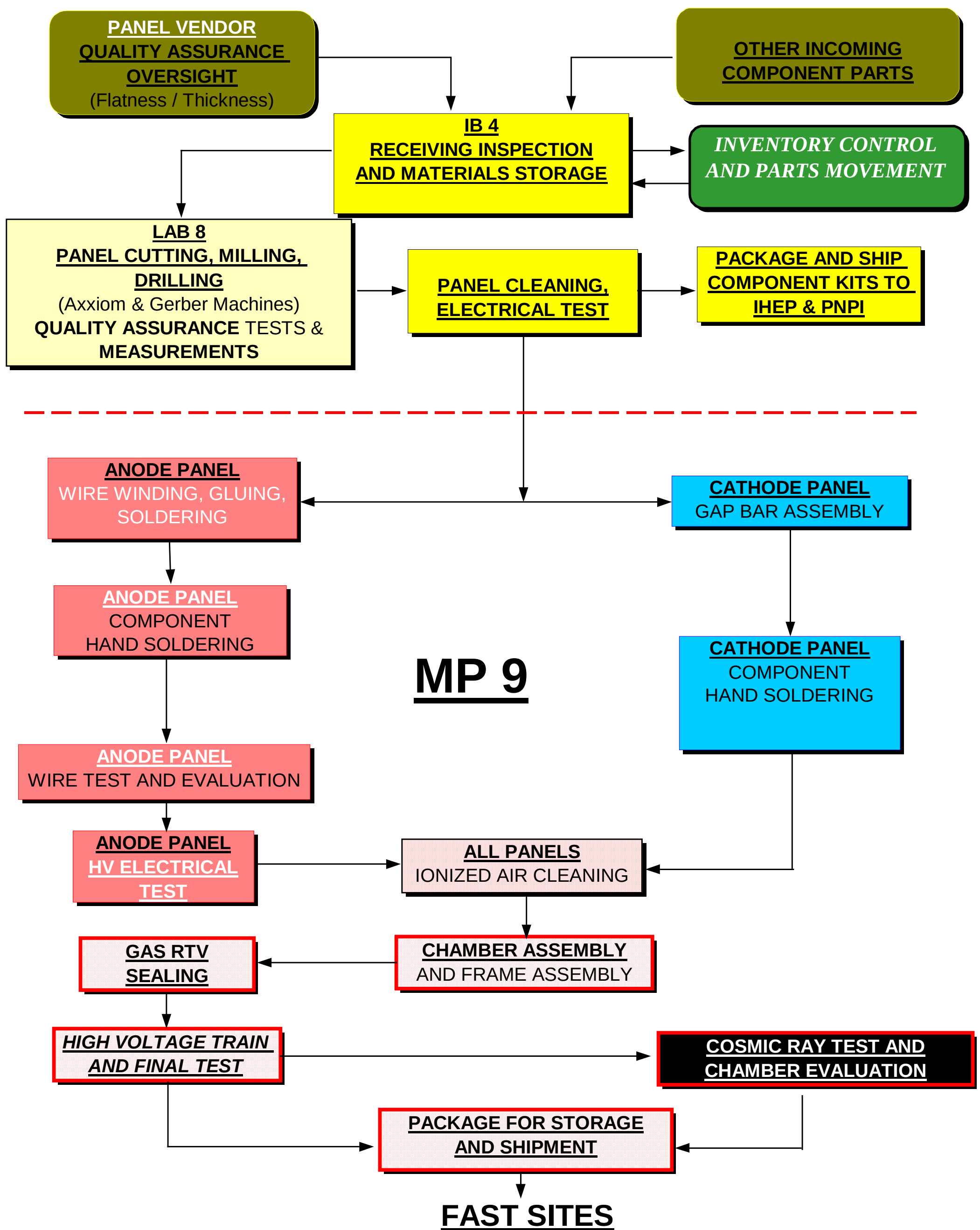
ATTACHMENT III

EMU Chambers Production Drawings Approval



ATTACHMENT IV

Fermilab Plan
CMS Muon Chamber Production
Production Flow



Revision History

Version	Date	Section No.	Specifics
1	08/18/2000	All	First version

Controlled Distribution

Technical Division library	
CMS-CSC FNAL Site Manager	Giorgio Apollinari
CMS-CSC Project Engineer	Nelson Chester
Technical Division Quality Assurance Officer	Jamie Blowers

CMS-EMU FNAL Factory
Division of Responsibilities

November 30th, 1999

This **CMS-EMU FNAL Factory Division of Responsibilities** covers the assignment of tasks and responsibilities for personnel operating the manufacturing and testing sites of the CMS-EMU Factory at Fermilab. As such, this is a working document, which may require modification as the need for new resources and/or new tasks are identified.

Fermilab will assemble approximately 148 chambers and will provide kits for additional 224 smaller chambers to be assembled at PNPI (Russia) and IHEP (China). Personnel required for tooling development, product development, quality assurance, and floor management will be provided jointly by PPD, TD and the CMS Muon Project.

1. FNAL Site Management

1.1. Site Manager

1.1.1. The Site Manager (Giorgio Apollinari) will have full management responsibility for the procurements of parts and fabrication of the chambers and chamber kits.

1.1.2. The Site Manager, upon consultation with the Project Engineer, will have primary control over the activation or deactivation of the factory line.

1.1.3. The Site Manager will be responsible for the CMS Endcap Muon Chambers performance in accordance with the CMS-EMU Technical Specifications and any modification/addition provided by the CMS-EMU L2 and L3 Managers (Gena Mitselmaker and Andrey Korytov respectively).

1.1.4. The Site Manager will report on the FNAL part of the Project Cost and Schedule. He will report to the appropriate L2 and L3 CMS Muon Project Managers and to the US CMS Management Office according to the format established by the appropriate level of Management.

1.1.5. The Site Manager will approve procurements for the CMS-EMU factory in agreement with the CMS project Cost Estimate. In agreement with the appropriate L2-L3 managers, he will provide general guidelines for the finalization of R&D tasks and the transition to production.

1.1.6. The Site Manager will act in agreement with the approved Resource Loaded Schedule in the definition of the FNAL factory tasks.

1.2. Project Engineer

1.2.1. The Project Engineer (Nelson Chester) has control over all the engineering aspects of the factory. These aspects include tooling design, chamber drawings, assembly procedures and technical specifications.

1.2.2. The Project Engineer has full responsibilities for the sign-off of Discrepancy Reports (DR) and the initiation of Engineering Change Requests (ECR). He can delegate the DRs sign-off to the Production Floor if he elect to do so. He will seek advice from the project Technological Physicists (Oleg Prokofiev and Yuri Pishialnikov) when needed.

1.2.3. The Project Engineer will review the setup of chamber assembly at FNAL and at the remote sites (FAST Sites at University of Florida and University of California at Los Angeles) providing guidance where needed.

1.3. Foreign Sites Coordination

1.3.1. The Foreign Site Coordinator (Victor Yarba) will work in consultation with the Site Manager and will have control and responsibility for the coordination of activities with the foreign assembly sites (PNPI, Russia and IHEP, China).

1.3.2. The Foreign Site Coordinator will be responsible for gathering the proper information from the Foreign Assembly Sites representatives to help and expedite the custom clearance of FNAL shipments through the foreign custom offices.

2. Engineering

2.1. General Aspects

2.1.1. The engineering group is headed by the Project Engineer. The Project Engineer has full control and responsibility for the engineering group, which includes the chamber and tooling engineers (Vladislav Razmyslovitch and Evgeni Borissov respectively), any draftsperson needed for drawings finalization and any engineer visiting from the foreign assembly sites.

2.1.2. The Project Engineer will have responsibility for the production of all the chamber and tooling drawings, their checkout, the drawing release and the purchase release to maintain production according to the CMS-EMU schedule.

2.1.3. The Project Engineer will be responsible for the integration of other institution drawings (Wisconsin) in the TD-FNAL system and the checkout of those drawings for appropriate use on the production floor.

2.1.4. The Project Engineer will act as advisor for production activities at FAST Site and at the foreign assembly sites.

2.1.5. Prompted by the US CMS Managers and/or the appropriate L2-L3 managers, the Project Engineer will edit, update, and seek required approvals for release of all technical specifications and engineering drawings.

2.1.6. The Project Engineer will initially release and maintain all the released specifications and technical drawings, entering them in the TD Document Control System (DCS) and in the CERN Drawings Database. All released drawings and specifications will be assigned Fermilab part numbers.

2.1.7. The Project Engineer will be responsible for distributing released drawings and specifications and documenting all the engineering changes and the disposition of non-conforming materials during the course of production.

2.2. Drawings Preparation

2.2.1. The Chamber Engineer (Vladislav Razmyslovitch) will be responsible for providing, releasing after approval, and controlling through the appropriate TD procedures, all sets of the final chamber drawings prior to the Design Review and the beginning of production (ME234/2) or prior to parts shipments to the foreign sites.

2.2.2. The Tooling Engineer (Evgeni Borissov) will be responsible for providing, releasing after approval, and controlling through the appropriate TD procedures, all sets of the final tooling drawings prior to the beginning of production or shipment to the foreign sites.

2.2.3. The Project Engineer is responsible for acknowledging the need and requesting from the Site Manager appropriate resources for the documentation of the electrical and electronic circuit of the production tooling.

2.3. Drawings Sign-off

2.3.1. The Project Engineer only will be responsible for the drawings sign-off. When convenient, he may delegate the actual signing process to the Site Manager or another person of his choice.

2.4. Purchase Releases

2.4.1. The Project Engineer or the Site Manager will generate the purchase releases for the procurement of production parts according to the CMS-EMU schedule.

2.4.2. To insure procurement to the proper drawing or technical specifications, all purchase releases will be submitted or verbally approved by the Project Engineer.

2.5. Technical Specifications

2.5.1. Technological Physicists and Production Floor Managers will be responsible for communicating to the Project Engineer the proper technical specifications for parts and tooling needed for the chamber assembly.

2.5.2. The Project Engineer will be responsible for editing and maintaining the project technical specifications, assigning them appropriate document control numbers.

3. Procurement & Inspection

3.1. Parts Procurement

3.1.1. The Procurement & Inspection Group (Gregg Kobliska) will be responsible for the procurement of parts for the CMS-EMU project. Procurement will take place from vendors or Universities, based on directions from the Site Manager and Project Engineer.

3.1.2. The Procurement Group will act on Purchase Releases generated by the Site Manager/Project Engineer and processed through the Process Engineer Group (Bob Jensen) by T.J. Gardner. The Procurement Group will work on drawings released and stored in the TD DCS System and generate Purchase Requests in the most expeditious way.

3.1.3. In very exceptional circumstances, when a procurement is urgent and the released process may not be fast enough to provide the Procurement Group with the latest version of a drawing, the Project Engineer is responsible for providing a copy of the latest version of a released drawing for Procurement.

3.2. Parts Inspection

3.2.1. All the parts will undergo inspection with a sampling determined by experience and agreed upon between the Inspection Group and the Site Manager/Project Engineer.

3.2.2. The Project Engineer will be responsible for providing the Inspection Group with documentation indicating the critical dimensions to inspect in any part of the CSC Chambers.

3.2.3. Non-discrepant parts will be documented following the standard TD practice. The Inspection group will be responsible for stocking and documenting the parts appropriate for production and for replacement of the discrepant parts, according to directions from the management.

3.2.4. The Inspection group will be responsible for pointing out inadequacies-mistakes in the drawings. The Project Engineer will be responsible for the drawing correction and re-release.

4. Kits Preparation and Shipping

4.1. Chamber Kits for FNAL

4.1.1. Kits for the chambers to be assembled at Fermilab will be prepared and staged by the Pro-Eng group. T.J. Gardner will have responsibility for obtaining the appropriate Engineering Releases and Engineering Change Orders when applicable, and prepare kits to be staged before shipment to MP9 for chamber assembly. Chamber panels will not be part of these kits and will be delivered directly to the MP9 Floor Manager (G.Smith) from the Procurement and Inspection Group.

4.1.2. When necessary, the MP9 Inventory Control Expert (Lamar Lee) will have responsibility for releasing in a timely manner Additional Parts to the production floor. When the necessity of an Additional Part Release arises from a drawing inaccuracy, the MP9 Inventory Control Expert will have the responsibility of notifying the Site Manager/Project Engineer. Additional Parts requests can be process directly by the MP9 Inventory Control Expert without the Site Manager/Project Engineer approval, to expedite the delivery of parts on the production floor. The MP9 Inventory Control Expert will have responsibility for recording and documenting the parts delivered to the Production floor through Additional Part Requests.

4.1.3. The Site Manager will communicate the schedule for Kits preparation after consultation with the MP9 Floor Manager during the pre-production stage (FY 2000). During production, the MP9 Floor Manager will schedule the delivery of kits to MP9 according to the production needs.

4.1.4. Transportation of kits to/from the various assembly sites will be a responsibility of the Procurement and Inspection group.

4.2. Chamber Kits for China-Russia

4.2.1. Kits for chambers to be assembled in China (IHEP) and Russia (PNPI) will be prepared by the Pro-Eng group. T.J. Gardner will have responsibility for obtaining the appropriate Engineering Releases and Engineering Change Orders when applicable, and prepare kits to be shipped to IHEP or PNPI. Chamber panels will be part of these kits.

4.2.2. When necessary, request for additional parts from the foreign sites will be transmitted to the Procurement and Inspection group. After approval from the Site Manager/Project Engineer, T.J. Gardner will have responsibility for releasing on a timely manner Additional Parts to Russia and China.

4.2.3. The Site Manager will communicate the schedule for Kits preparation after consultation with the L2-L3 Managers.

4.2.4. Transportation and shipment of kits will be the responsibility of the Procurement and Inspection group.

4.2.5. Design of the containers for the kit shipment will be a responsibility of the Engineering group. Kits will be prepared in a location agreed upon by the Pro-Eng group and the Procurement and Inspection group.

5. Production Tooling

5.1. FNAL Tooling

5.1.1. Responsibilities for chamber production tooling in MP9 is assigned according to the document “PPD-TD Agreement”. In general, mechanical responsibility lies with the TD group, while responsibility for the electrical and electronics support lies with PPD.

5.1.2. The Site Manager and/or Project Engineer may delegate maintenance responsibilities for the Fermilab tooling to the proper experts.

5.2. PNPI/IHEP Tooling

5.2.1. Critical tooling for IHEP and PNPI will be assembled, commissioned and debugged in MP9. The Site Manager/Project Engineer will assign responsibility for the tooling preparation in accordance to individual capabilities and resources availability.

5.2.2. The MP9 Floor Manager (Glenn Smith) has responsibility to provide floor space and, if needed, manpower for the mechanical assembly of the critical tooling.

5.2.3. The CMS Project Electrical Support Technician (Curtis Danner) will have responsibility for the installation and commissioning of the electrical components of the Tooling.

5.2.4. The MP9 Technological Physicist (O. Prokofiev) will have responsibility for the tooling commissioning and testing. The MP9 Technological Physicists, in conjunction with the Foreign Site Coordinator and the Tooling Engineer, will have responsibility for the preparation of documentation for shipment to the foreign sites.

6. Interfacilities Transfers

6.1. Transfers to/from Lab 8

6.1.1. Lab 8 is the facility where panels are cut, drilled and machined for further needs of the factory. Lab 8 will machine all the panels of the EMU project, including the panels destined to China (IHEP) and Russia (PNPI).

6.1.2. The Procurement and Inspection group will have responsibility for transfering raw panels to Lab 8 and machined panels from Lab 8 into the designated storage area.

6.1.3. The Lab 8 Floor Manager (P. Deering) will have responsibility for requesting transfer of panels to the Procurement and Inspection group.

6.1.4. The Lab 8 Floor Manager will have responsibility to request raw panels to maintain the highest production rate with no delay or slowdown due to non-machine related problems, like lack of access to the building or floor plan modifications. The Lab 8 Floor Manager will also have responsibility for allocating floor space for the needs of the CMS-EMU factory.

6.2. Transfers to/from MP9

6.2.1. MP9 is the facility where all kits and panels will converge for the CMS-EMU chamber assembly.

6.2.2. The Procurement and Inspection group will have responsibility to deliver to MP9 kits for chamber assembly (panels excluded) upon communication from the kits originator (T.J.Gardner) and the MP9 Floor Manager (Glenn Smith).

6.2.3. The procurement and Inspection group will be responsible for delivering to the MP9 Floor Manager panels for cleaning and further assembly in the designated cleaning area. The subsequent transfer of panels to the MP9 factory, if necessary, will be a responsibility of the MP9 floor Manager.

6.2.4. After completion and certification, chambers will be stored in shipping containers. The Procurement and Inspection group will be responsible for shipment to the FAST sites upon communication from the MP9 Floor Manager. If immediate shipment is not possible, the Procurement and Inspection group will be responsible for storing and tracking the chambers in a designated storage area.

6.3. Transfer to/from Lab 7

6.3.1. Lab 7 is the facility where chambers can be tested using a Cosmic Ray setup. The expectation is that Lab 7 will receive only the prototypes produced at MP9 (~5 chambers) and no more than 5-10% of the chambers produced by the factory (~10 chambers) for purposes of QC. All the other chambers will be shipped to the FAST sites without a cosmic ray test at Lab 7.

6.3.2. The Procurement and Inspection group will be responsible for delivering chambers from MP9 to Lab 7 upon communication from the Site Manager and the MP9 Floor Manager. The same group will have responsibility to place the chamber on the cosmic ray stand following standard safety practices.

6.3.3. When a chamber needs to be shipped from Lab 7, the Procurement and Inspection group will be responsible for removing the chamber from the cosmic ray stand, load it in the shipping container and move it to "Shipping and Receiving".

6.3.4. The designation of containers for shipment will be a responsibility of the Engineering group.

7. Lab 8 Production

7.1. Production Travelers

7.1.1. Travelers Drafting

The Technological Physicist in Lab 8 (Y.Pischalnikov) will be responsible for drafting travelers in Lab 8. The Technological Physicist will also be responsible for proposals to modify and draft travelers for panels whenever new procedures, improvements or better instructions need to be included in the manufacturing process.

7.1.2. Travelers Revision

The Pro-Eng group and the Lab 8 Floor Manager will revise the Lab 8 procedures and engineer them for the production process.

7.1.3. Travelers Sign-off

The Site Manager and Project Engineer will sign-off the travelers. The Pro-Eng group will manage travelers.

7.1.4. The Pro-Eng group will control and manage the travelers. The Pro-Eng group will be responsible for updating the travelers when changes become necessary with inputs from the Technological Physicist or the FNAL Site Management.

7.1.5. The Pro-Eng group will be responsible for the collection of travelers from different production sites (Lab 8, MP9, and Lab 7) and their consolidation in a chamber book. The Pro-Eng group will also be responsible for scanning the travelers and storing them in electronic format.

7.1.6. The Pro-Eng group will be responsible for collecting the QA/QC measurements and panels parameters from the Lab 8 production.

7.2. Parts Control

7.2.1. Incoming/Outgoing Panels

7.2.1.1. The Site Manager will be responsible for specifying the panels production schedule in agreement with the overall CMS-EMU project schedule and FNAL responsibilities for panels delivering to the foreign assembly sites.

7.2.1.2. The Lab 8 Floor Manager will be responsible for notifying the TD Procurement group about the necessity of transferring to Lab 8 raw panels for machining. TD Procurement group will act on a simple notification from Lab 8 Floor Manager.

7.2.1.3. The Lab 8 Floor Manager will be responsible for allocation of floor space for incoming and outgoing panel boxes.

7.3. Documentation, Training and Tooling Maintenance

7.3.1. Drawings

7.3.1.1. The TD Pro-Eng group will be responsible for transferring to Lab 8 released drawings of panels for manufacturing.

7.3.1.2. The Lab 8 Floor Manager will be responsible for proper storage and handling of the released drawings.

7.3.2. Tools Operation

7.3.2.1. The Lab 8 Floor Manager will be responsible for proper maintenance, operating instructions and personnel training of the machining tools (Gerber and Axxiom machines) in Lab 8. In particular the Floor Manager will institute proper maintenance contracts (or other maintenance procedure agreed upon by the FNAL Site Management), financed by PPD, with outside contractors to insure continued operations of the Gerber and Axxiom machines. The Floor Manager will be responsible for training PPD personnel on the usage and operation of the machines and for writing proper instructions and procedures. The Lab 8 Floor Manager will also be responsible for the simple tooling used for panel deburring and holes chamfering.

7.3.2.2. The TD Engineering group will be responsible for proper maintenance, operating instructions and personnel training of the strip position measuring devices. The Lab 8 Technological Physicist will be responsible for training PPD personnel on the usage and operation of the machines and for writing proper instructions and procedures.

7.4. Production Tasks and Production Flow

7.4.1. The Lab 8 Floor Manager will be responsible for monitoring production and report to the Site Manager on a weekly basis the status of activities in Lab 8 and the progress on panel production. Weekly meeting and e-mail messages are adequate for this information transfer.

7.4.2. The Lab 8 Technological Physicist will represent the FNAL Site Management in the study of possible improvements of the production flow and/or the modification of production tasks to achieve the specifications listed in the assembly drawings. The Lab 8 Technological Physicist will also be responsible for the initial monitoring of the production quality, and for the analysis, during production, of the quality level and the CMS-EMU database entries.

7.4.3. The Lab 8 Site Manager will have sole authority to direct the Factory work force in the various aspects of panel production which includes panels cutting on the Axxiom and Gerber machines and panels deburring.

7.5. Quality Control and Quality Assessment

7.5.1. The Lab 8 Floor Manager will be responsible for the training of technicians in following the travelers and quality control procedures prepared by the Pro-Eng group.

7.5.2. The Pro-Eng group will be responsible for Quality Auditing on a regular basis to be defined by consultation between the Technological Physicist and the FNAL Site Management.

7.5.3. The Pro-Eng group will be responsible for the collection of Lab 8 travelers and the fill-up of the CMS-EMU database with the appropriate information.

7.5.4. The FNAL Site Manager will be responsible for transmitting to the Pro-Eng group the appropriate information to be saved on the CMS-EMU Database.

7.5.5. The Lab 8 Floor Manager will be responsible for communicating to the Pro-Eng group the presence of discrepancies. The Pro-Eng group will be responsible for the documentation of the discrepancies. The implementation of action items determined by discrepancies will be a responsibility of the Lab 8 Floor Manager.

8. MP9 Production

8.1. Production Travelers

8.1.1. Travelers Drafting

The Technological Physicist in MP9 will be responsible for the drafting of travelers in MP9. The Technological Physicist will also be responsible for proposals to the modification and drafting of travelers for new panels whenever new procedures, improvements or better instructions need to be included in the manufacturing process.

8.1.2. Travelers Revision

The Pro-Eng group and the MP9 Floor Manager (G.Smith) will revise the MP9 travelers, verify their accuracy versus the released drawings and engineer them for production.

8.1.3. Travelers Sign-off

The Site Manager and Project Engineer will sign-off the travelers.

8.1.4. The Pro-Eng group will control and manage the travelers. The Pro-Eng group will be responsible for updating the travelers when changes become necessary with inputs from the Technological Physicist or the FNAL Site Management.

8.1.5. The Pro-Eng group will be responsible for collection of travelers from different production sites (Lab 8, MP9, and Lab 7) and their consolidation in a chamber book. The Pro-Eng group will also be responsible for scanning the travelers and storing them in electronic format.

8.1.6. The Pro-Eng group will be responsible for the database collecting parameters from the MP9 Chamber Production.

8.2. Tooling Procedures

8.2.1. The FNAL Site Management will assign the drafting Tooling Procedures to the most appropriate tooling expert. These assignments will take place through verbal communication, e-mail or during a weekly meeting.

8.2.2. The MP9 Technological Physicist will be responsible for the documentation of new proposal or changes in the tooling procedures. The FNAL Site Management will evaluate the new proposals. If approved, they will be documented and transmitted to the MP9 Floor Manager.

8.2.3. The MP9 Technological Physicist will be responsible for the maintenance of the gas system in MP9.

8.2.4. Revision and engineering of the tooling procedures will be a responsibility of the Pro-Eng group. The Pro-Eng group will also be responsible for engineering and drafting the procedures for tools used at the foreign assembly sites (PNPI, Russia and IHEP, China).

8.3.Parts Control

8.3.1. The FNAL Site Management will be responsible for specifying the chamber production schedule in agreement with the overall CMS-EMU project schedule. Parts will be delivered to MP9 in panels and kits.

8.3.2. Incoming Panels

8.3.2.1. Panels for FNAL production will be released to the MP9 Floor Manager prior to their cleaning. It will be a responsibility of the MP9 Manager to arrange panel transportation to MP9.

8.3.2.2. Panels for Foreign sites production will not be released by the Procurement group. MP9 will provide the manpower to clean the panels, but the Procurement group will keep responsibility for their tracking and subsequent shipment to the foreign sites.

8.3.3. Kits for FNAL Production

8.3.3.1. The MP9 Inventory Control Expert will be responsible for Kits control and Additional Parts Request whenever a kit is short in some components.

8.3.3.2. The MP9 Floor Manager will be responsible for allocation of floor space for incoming and outgoing kit boxes.

8.3.4. Outgoing Chambers

8.3.4.1. The MP9 Floor Manager will store boxes of completed chambers in the MP9 area (or other agreed location) until a box is ready for shipment to the US FAST Sites (University of Florida or UCLA). At that time, the MP9 Floor Manager will be responsible for notifying the TD Procurement group about the necessity of initiating the shipment.

8.4.Manpower Training

8.4.1. The MP9 Floor Manager will have responsibility to train the MP9 work force in reading the drawings and implementing the drawings indications.

8.4.2. The MP9 Floor Manager will have responsibility for training of the MP9 work force in the usage of the factory tools. The MP9 Floor Manager can access, at its discretion, the MP9 Technological Physicists or other Physicists in the project to provide guidance to the factory work force.

8.4.3. The MP9 Technological Physicist will have responsibility for training the factory work force in the usage of the equipment for the various open air HV tests.

8.5.Production Tasks

8.5.1. The MP9 Floor Manager will be responsible for monitoring production and report to the FNAL Site Management on a weekly basis the status of activities in MP9 and the progress on Chamber production. Weekly meeting and e-mail messages are adequate for this information transfer.

8.5.2. The MP9 Technological Physicist will represent the FNAL Site Management in the study of possible improvements of the production flow and/or the modification of production tasks to achieve the specifications listed in the Assembly Drawings. The production physicist will also be responsible for the initial monitoring of the production quality, and for the analysis, during production, of the quality level and the CMS-EMU database entries.

8.5.3. The MP9 Floor Manager will have sole authority to direct the Factory work force in the various aspects of chamber production which includes panel gluing, winding, soldering (both automatic and discrete components soldering), panel HV test in air, chamber assembly, sealing and leak testing.

8.5.4. The Purdue University group will have responsibility for Tension testing, wire position measurements and Capacitance measurements on all the panels going through production in MP9.

8.5.5. The MP9 Production Physicist will have responsibility for the HV training of a completed chamber.

8.6. Quality Control and Quality Assessment

8.6.1. The MP9 Floor Manager will be responsible for the training of technicians in following the travelers and quality control procedures prepared by the Pro-Eng group.

8.6.2. The Inventory Control Expert will be responsible for Quality Auditing on a regular basis to be defined by consultation between the Technological Physicist and the FNAL Site Management.

8.6.3. The Pro-Eng group will be responsible for the collection of MP9 travelers and the fill-up of the CMS-EMU database with the appropriate information.

8.6.4. The FNAL Site Management will be responsible for transmitting to the Pro-Eng group the appropriate information to be saved on the CMS-EMU Database.

8.6.5. The MP9 Floor Manager will be responsible for communicating to the Pro-Eng group the presence of discrepancies. The Pro-Eng group will be responsible for the documentation of the discrepancies. The implementation of action items determined by discrepancies will be a responsibility of the MP9 Floor Manager.

8.6.6. Resolution of the MP9 discrepancies will be the sole responsibility of the FNAL Site Manager or the Project Engineer.

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